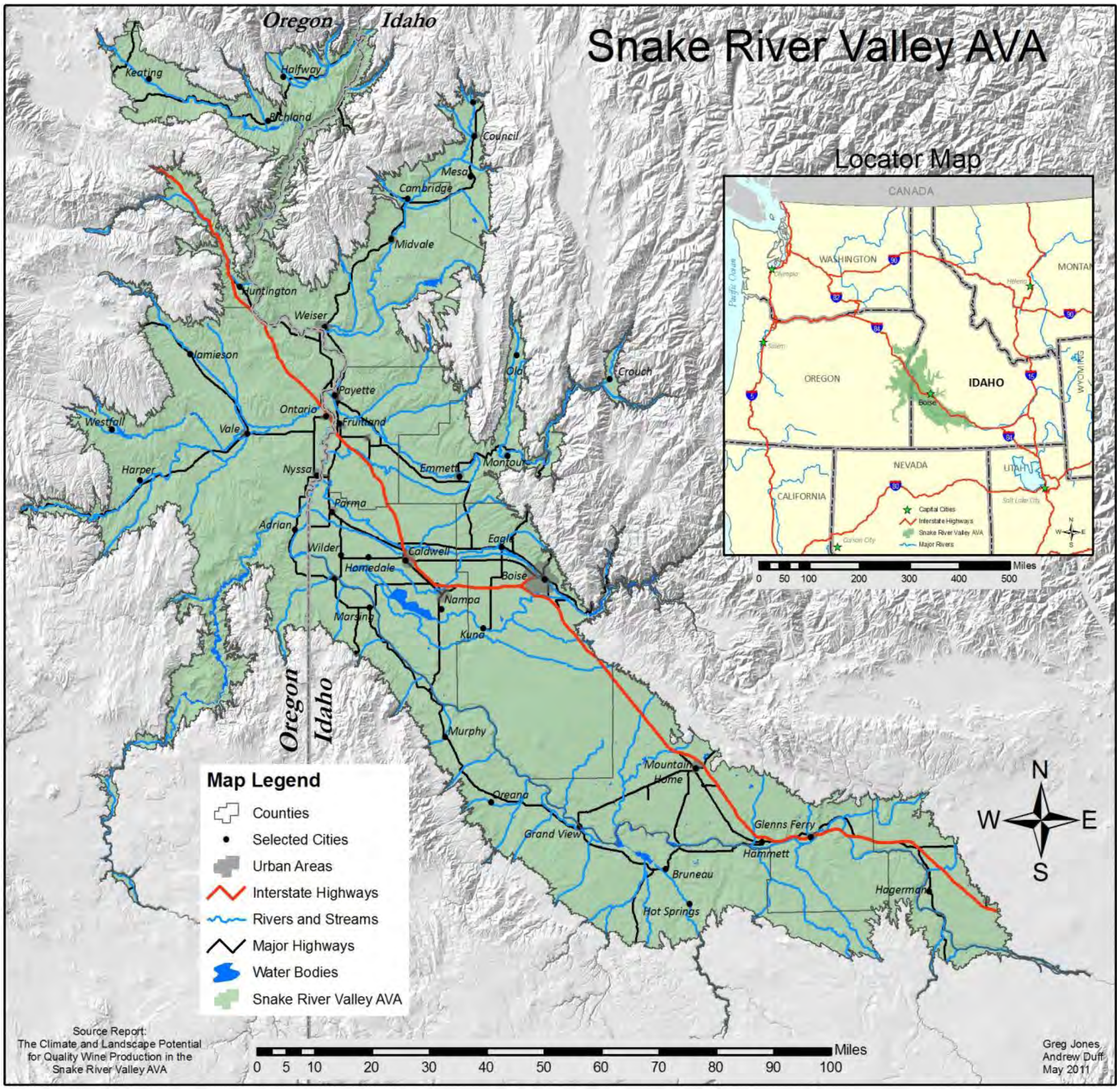
The Climate and Landscape Potential for Quality Wine Production in the Snake River Valley AVA



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Executive Summary:

A region's potential for growing grapes for quality wine production requires a sound understanding of the suitability of the region to provide the landscape and climate factors necessary for ripening different varieties. While some regions have had decades and even hundreds of years to define, develop, and understand their suitability, newer regions typically face a trial and error stage of finding the best match between region, site and variety. This research facilitates this process by modeling the climate and landscape in the Snake River Valley American Viticultural Area (AVA) of Idaho and Oregon. Wine production in Idaho has been one of the fastest growing agricultural commodities becoming the 2nd largest fruit crop in the state, representing nearly 20% of the total acreage. Established in 2007, the Snake River Valley AVA encompasses approximately 8,263 square miles over the Western Snake River Plain of Idaho and Oregon. Today there are over 60 vineyards consisting of over 1600 acres, providing fruit to over 40 wineries which crushed over 3000 tons and made over 200,000 cases in 2009. To support continued growth, this work adds to the current knowledge of the suitability for viticulture in the Snake River Valley AVA providing existing and new growers greater insight into the potential of the region.

The physical factors that influence suitability include matching a given grape variety to its ideal climate along with optimum site characteristics of elevation, slope, solar receipt, and soil properties. To analyze these factors, this research uses spatial data for the Snake River Valley AVA in a multi-layered Geographic Information System model that examines topographical influences, soil factors, land use zoning criteria, heat accumulation limits, and climate risk issues for growing grapevines. The results show that the region has just over 30,000 hectares of land (1.5% of the AVA) which has very good to exceptional landscapes for viticulture (topographic and soil characteristics). From a climate perspective, the baseline suitability of the AVA shows a cool to warm climate growing environment with the region experiencing a range of 1500-3300 growing degree-days. An analysis of climate risk (spring and fall frost and the length of the frost-free period) shows that roughly 2% of the AVA has relatively low risk, which matches much of the ideal topographic and soil areas.

A comparison of the existing vineyards with the modeled suitability zones finds overall good agreement with most locations planted on good to excellent landscapes (topography and soils). While some variations from the ideal landscapes can be found, overall the results show that growers in the region have generally made good site selection decisions. From a climate perspective, the existing vineyards are equally divided between cool to warm climates for growing degree-days (Winkler Region Ib and Region II) and exhibit low to moderately high frost risk. Given the region's current climate structure, experiences from existing growers and variety trials at the USDA-ARS Horticultural Crops Research Laboratory at Parma the Snake River Valley AVA is clearly suitable to many of the varieties currently planted in the region. These would include, but are not limited to, Chardonnay, Pinot Gris, Riesling, Pinot Noir on the cooler sites; Sauvignon Blanc, Cabernet Franc, Tempranillo, and Dolcetto on the intermediate sites; and Merlot, Malbec, Viognier, Syrah, Cabernet Sauvignon, and Grenache on the warmest sites. Probably the most limiting issue is frost and the length of the growing season; choosing optimum sites and varieties that bud late and ripen early while needing moderate heat accumulation will minimize the risk.

Overall, the Snake River Valley AVA is an extremely viable and promising region for winegrape production. It's relatively short history of viticulture and wine production have shown the potential to ripen numerous cool to warm climate grape varieties to high quality. Rapid growth of the industry is likely to continue as it gains further recognition in the market and captures the potential available from a large amount of suitable land.

Introduction:

Vineyard site selection is the single most important decision that any potential grape grower will make. Combined with matching the site to a grape variety, this decision will ultimately affect the vineyard's yield, the quality of the wine produced, and the vineyard's long-term profitability (Wolf, 1997; Jones and Hellman, 2003). Overall, the quality of wine produced in any viticultural region comes primarily from the high quality of the grapes, which are carefully crafted in the winery. The quality of the grape, however, is the result of the combination of five main factors: the climate, the site/local topography, the nature of the soil, the choice of the variety, and how they are managed to produce the best crop. The French have named this interaction between the local environment, the vines, and the people the "terroir" with the history of Old World viticulture showing its importance for quality winegrape production (for a good review see Vaudour, 2002). From this history, it is clear that the prudent grape grower must understand the interactions between these factors, their controls on grape growth and quality, and maximize a given site's characteristics to produce the best possible fruit at a profit.

Idaho has a rich agricultural heritage that began with the arrival of immigrants who settled the west. Today Idaho ranks 23rd in the United States in the total value of all agricultural products sold ($5.7 billion; USDA, 2010). By crop Idaho ranks 1st in potatoes, 2nd in vegetables, 3rd in barley, 11th in wheat, and 18th in forage (hay and other forage products) in the United States. At the state level potatoes are the number one crop followed by wheat, hay and alfalfa, then numerous grains, dry beans, lentils, and peas, followed by peppermint, and hops. Over the last decade winegrapes have been one of the fastest increasing agricultural commodities becoming the 2nd largest fruit crop in the state, representing 18% of the total acreage (USDA, 2006). To facilitate the growth and potential of the Idaho wine industry the purpose of this research is to examine the climate and landscape in the Snake River Valley American Viticultural Area (AVA) in Idaho and Oregon (Figure 1). Through the spatial analysis of topography, soil, land use, and climate this work aims to provide a comprehensive assessment that helps the region realize its potential by facilitating more precise site selection. The results will allow growers to make more informed planting decisions, which should ultimately drive an overall increase in production and quality as the region develops further. As the region becomes more recognized for the uniqueness and quality of its grapes and wine, growers will become economically more viable and sustainable.

In the sections that follow, this report 1) details the physical factors important for growing quality fruit for wine production, 2) provides an overview of the history of viticulture and wine production in Idaho, 3) discusses the physiography of the region, 4) examines the historic, current, and future climate suitability for wine production, 5) develops a model that examines the suitability for viticulture in the region, and 6) compares the model results with existing vineyards in the region.

Overview of Climate, Landscape, and Soil Requirements for Viticulture:

Assessing a region's, and even more importantly a site's physical environment is arguably the single most important decision process that any potential grape grower will encounter when considering to grow winegrapes (Jones and Hellman, 2003). Combined with matching the region/site to the most suitable grape varieties, this decision will ultimately affect the vineyard's yield, the quality of the wine produced, and the vineyard's long-term profitability (Wolf, 1997). However, it should be stressed that site selection will almost always require compromises, in that few sites will possess ideal landscape and climate characteristics in every respect. Regional or site suitability assessment represents a complex suite of issues that must be factored into any plan to establish a successful vineyard operation. Numerous overviews exist that detail region and site selection in general (e.g., Dry and Smart, 1988; Gladstones, 1992; Wolf, 1997) or for specific regions (e.g., Shaulis and Dethier, 1970; Davis et al., 1984; Sayed, 1992; De Villiers, 1997; Boyer and Wolf, 2000; Carey, 2001; Jones and Hellman, 2003; Jones and Light, 2001; Jones; 2003; Jones and Duff, 2007) and focus mostly on climate, topography, and soil factors using spatial data analysis. Below is a general overview of these requirements that leads to the development of a terroir zoning model depicting the best potential sites in a given region.

Climate Requirements

Overall, climate exerts the greatest influence on the ability of a region or site to produce quality grapes (van Leeuwen et al. 2004). The average climate structure of an area has proven to determine to a large degree the defining wine style, with variations in wine production and quality being chiefly controlled by vineyard management decisions and short-term climate variability (Gladstones, 1992; Jones, 1997). In general, grapevines need a growing season of sufficient length with enough sunlight hours and heat energy to allow both the fruit and the vegetative parts of the vine to mature. Growing season lengths over 180 days are considered to be the most suitable for the majority of grape varieties (Jones, 1997). Growing season lengths can be assessed for any region or site by examining the number of days between the 28-32°F frost points (28°F is the freezing point of most green tissue, but 32°F can be damaging depending on the growth state of the vine). A growing season should also be largely free of heat extremes where prolonged daytime maximum temperatures over 95-100°F can cause grapevines to be stressed and not produce to their optimum (Gladstones, 1992). Research shows that grapevines experience the best whole vine accumulation of photosynthates between 70-80°F, reaching a maximum for single leaf photosynthesis near 90°F (Mullins et al. 1992). A region or site should also provide a growing season with some precipitation for soil moisture, but be at a minimum during the principal growth stages of bloom and ripening when too much rain can affect flowering and fruit set and the quality of the ripening fruit. Finally, a region or site should not experience consistently high winds and be largely free of extreme weather events such as hail.

Arguably the most important and most commonly used gauge of regional/site suitability is the assessment of heat accumulation (Jones et al. 2010). This is normally done using various formulations of growing degree-days (GDD), which attempts to quantify heat available for vine development during the growing season. The most common formulation for growing degree-days for viticultural suitability is the accumulation of degrees above a base temperature of 50°F (the minimum for plant growth) between April 1st and October 31st. The resulting values are typically used to place broad bounds on suitability with the most common being the designation of Winkler regions (Table 1) which were developed for California (Amerine and Winkler, 1944). Examples of some other wine areas in terms of Winkler classes include Region I – Champagne, Burgundy, the Willamette Valley, the Rhine Valley; Region II – Bordeaux, Umpqua Valley; Region III – Mendocino, Sonoma; Region IV – Napa Valley; Chianti; Region V – Fresno, Bakersfield. However issues with the Winkler region degree-day system include not being ideally suitable everywhere, no lower or upper bounds specified for Regions I or V, and the values do not differentiate between gradations of cool climate suitability in many regions in the western United States and other regions worldwide (Gladstones, 1992; Jones, 1997; Moulton and King, 2005; Jones et al. 2010). To address the last two issues described above Jones et al. (2010) examined GDD over the western United States, establishing a lower bound for Region I, and upper bound for Region V, and a division of the lower class into Region Ia and Ib. The result is a better depiction of the cool climate limits for viticulture and an important division between the earliest cool climate varieties (Region Ia), which are often hybrids, and typical *V. Vinifera* cool climate varieties (Region Ib).

Table 1 – Winkler region growing degree-day limits (Amerine and Winkler, 1944), updated by Jones et al. (2010), and types of fruit or wine expected in each class.

Region	Degree-Days	Suitability
Region Ia	1500-2000	Only very early ripening varieties achieve high quality, mostly hybrid varieties and some *V. Vinifera*
Region Ib	2000-2500	Only early ripening varieties achieve high quality, some hybrid varieties but mostly *V. Vinifera*
Region II	2500-3000	Early and mid-season table wine varieties will produce good quality wines.
Region III	3000-3500	Favorable for high production of standard to good quality table wines.
Region IV	3500-4000	Favorable for high production, but acceptable table wine quality at best.
Region V	4000-4900	Typically only suitable for extremely high production, fair quality table wine or table grape varieties destined for early season consumption are grown.

Topographic Requirements

The topography and soils of a site play important roles in grapevine growth and quality, and have interactive effects with climatic elements (van Leeuwen et al. 2004). Topographic factors that exert the greatest influence on a site's climate include elevation, slope, aspect, hill isolation and how it affects air drainage, and proximity to bodies of water. A marginal climate can be mitigated to some degree by locating the vineyard on an ideal site. Through examining vineyard landscapes worldwide, Gladstones (1992) found that the very best sites will usually have two or more of the following features:

- They are on slopes with excellent air drainage, and are usually situated above the fog level in a thermal zone.
- The very best are usually on the slopes of projecting or isolated hills that enhance air drainage.
- The slopes directly face the sun during at least some part of the day. South facing is best with easterly aspects receiving morning sun and westerly aspects receiving the afternoon sun (Northern Hemisphere) (Table 2).
- If inland, they tend to be close to substantial rivers or lakes. Additionally, mountain/valley breeze locations during the summer are important.

When inspecting a site's topography, components of elevation, slope, aspect, and hill isolation should be examined individually, but evaluated collectively since it is their interactive effect on grape production that is crucial (Jones and Hellman, 2003). While very few sites will have the perfect blend of each component, there are some general guidelines to follow. First, the effects of a site's elevation can be assessed from both absolute and relative standpoints. Overall, absolute elevation above sea level determines the general climatological characteristics of a site's temperature regime. On the average, temperature changes 1.0ºF per 300 feet of elevation. This effect can leave higher elevation sites with fewer growing degree-days, which can retard vine growth and fruit maturation. Frost probabilities also increase at higher elevations. The relative elevation of a site, the local relief from a valley bottom to the site's elevation, largely determines the air drainage and slope temperature variations.

Slope is the degree of inclination of the land, which is measured as the angle of the drop in elevation over a horizontal distance. Both slope and aspect play important roles in sunlight reception (Table 2), cold air drainage, and frost and wind protection. Given that much of viticulture is done at the climatic limits of suitability to provide the highest quality, most growers take advantage of sloping sites, which alter the angle of incidence of the sun's rays that strike the surface. This effect can be substantial; a vineyard with a 10 degree south-facing slope can receive as much as 25% more insolation than a flat site. Greater insolation increases the growing degree-days, so a south-facing slope will be warmer, promoting earlier ripening (Table 2). A sloped site also enables cold air to drain away, reducing the risk of frost damage. Hillside sites, however, have increased risk of soil erosion, higher vineyard management costs, and present a greater hazard for operating equipment (Coombe and Dry, 1988). Erosional forces increase in direct proportion to increases in slope, and may experience slow downhill soil creep unless preventive practices are employed.

A site's aspect describes the compass direction in which the slope faces and in general southeast to west aspects are favored for maximum sunlight receipt (Table 2). Depending on numerous other factors such as obstructing trees, other hills and rock outcroppings, a properly situated slope can enhance growth and maturation or limit disease problems (Jackson and Schuster, 1987). For any site in the Northern Hemisphere, northwest, north, and northeast tending sites will experience delayed grape growth stages, lower sunlight and heat receipt, and slower soil and canopy evaporation. Southeast, south, southwest, and west tending slopes will exhibit earlier grape growth stages and show varying increases in insolation, heat, and evaporation (Wolf, 1997).

Table 2 – Relative effects of site aspect (compass direction of slope) on climate characteristics and crop growth (adapted from numerous sources).

Parameter	*North*	*North East*	*East*	*South East*	*South*	*South West*	*West*	*North West*
Initial Growth in Spring	Retarded	Retarded	Retarded	Advanced	Earliest	Earliest	Advanced	Retarded
Potential for Spring Frost	High	High	Moderate	Less	Less	Less	Moderate	High
Speed of evaporation in the morning	Slow	Moderate	Rapid	Moderate	Slow	Slow	Very Slow	Slow
Daily Maximum Canopy Temperatures	Minimum	Less	Less	Less	Maximum	Greater	Greater	Less
Radiant heating of crops in summer	Minimum	Less	Less	Less	Maximum	Greater	Greater	Moderate
Water Needs	Low	Low	Moderate	Higher	Highest	Highest	Higher	Low
Radiant heating of beds in winter	Minimum	Less	Less	Moderate	Maximum	Moderate	Less	Less

Isolated or projecting hills or ranges of hills are of special interest because they provide a temperature-modifying effect compared to the surrounding valley floor by creating thermal zones and increasing the ability for cold air to drain away from the mid-slopes (Jones and Hellman, 2003). Cold air drainage occurs because cold air is heavier than warm air and tends to flow downhill as regions upslope cool more quickly. Cold air will drain downhill until impeded by an obstruction large enough to pool the cold air or until the flattening of the topography. If a slope is open to proper airflow, cold air pooling will generally not be a problem, but any obstruction of airflow, such as fences, treelines, windbreaks, *etc*. should be avoided or removed. Therefore an isolated hill allows cold air to be efficiently drained away, and with no new source of cold air, the isolated or projecting hill is in the thermal zone.

Soil Requirements

Soil characteristics are an extremely important factor in determining the potential success of a vineyard. However, high quality wines are made from grapes grown in many different types of soils with no single type considered ideal, but each soil imparts its own unique characteristic mouth-feel to a given variety (Wilson, 1998). Although most grapevines can be grown across a wide variety of soil types, the most important characteristics for optimum growth are good internal drainage, adequate depth, sufficient water holding capacity during dry periods, and a soil pH that is slightly less than neutral (Jones and Hellman, 2003). A typical well-drained soil is often characterized by a subsoil layer that has relatively uniform colors of brown, red, or yellow-orange. Soils that are poorly drained are more commonly gray or have alternating areas of reddish brown and gray color. Drainage is important to maintain open pore spaces for grapevine roots to access oxygen. Soils that do not drain very well are easily saturated with water, which eliminates the oxygen in the pore spaces. Such soils can remain saturated for extended periods of time producing situations where roots have little or no access to oxygen and cause suffocation, lower vine physiology, and eventually the death of the vine.

Soil depth for optimum vine growth is commonly recommended to be a minimum of at least 30 inches before reaching bedrock or impermeable layers (shallow bedrock, chemical or physical hardpans) (Dry and Smart, 1988). Too shallow of a soil will limit development of the root system and typically results in smaller vines with greater sensitivity to changes in soil moisture. To maintain vine balance in all types of moisture conditions, deeper soils provide grapevine roots better penetration and the ability to develop a larger root system. Furthermore, shallow soils that encounter a hardpan layer can greatly influence internal drainage.

While drainage is extremely important in vineyards, a soil's available water holding capacity (AWC) is important as those soils with adequate water holding capacity are at an advantage, giving vines the greatest ability to tolerate periods of moderate drought. Soils with a relatively high water-holding capacity can retain much of the rainfall or irrigation in the root zone of grapevines and provide a buffer for water consumption by the vines (Cass, 1999). Low water holding capacity, as is found in very sandy or cobbly soils, will not hold enough water for the vines and will require very frequent irrigation to maintain adequate soil moisture levels.

In terms of soil fertility, grapevines are actually easier to manage on soils of relatively low fertility because too high of fertility leads to more growth and greater expense and time is spent on canopy management. Soil pH gives an indication of fertility and nutrient balance with most ideal vineyard soils being found between 5.5 and 7.5 (Cass, 1999). Outside this range, nutrients may become out of balance, with deficiencies or toxic levels effecting vine uptake or beneficial relationships with microorganisms. Ideally, a vineyard soil will be relatively deep, well-drained, have good water-holding capacity, and provide a moderate fertility level with a proper balance of nutrients.

Information on soil characteristics is best determined by site analyses done by sampling from pits or trenches on the property. However, generalized spatial information on soils can be found in county Soil Surveys prepared by the USDA-Natural Resources Conservation Service (NRCS; 2010). Soil Surveys contain information describing the various soil types found in a region and their properties including average depth, drainage characteristics, water-holding capacity, and pH. This information is available both in digital data and in the form of maps; however Soil Survey maps are limited in their accuracy and should serve only as a general guide to the soil type(s) in your area.

Idaho, Oregon and the Snake River Valley AVA:

History of Viticulture and Wine Production

Idaho's grape growing and wine production history follows that of the neighboring states of Oregon and Washington with the arrival of German, Italian, and French immigrants to the Pacific Northwest. However, the wine production story of the region before Prohibition was one of an irregular history of isolated experiments (Pinney, 2007). This was especially the case at the turn of the 20th century with the winegrape production dominance of California and the threat of Prohibition making the risks of winegrowing in Oregon, Washington, and Idaho too great (Adams, 1990). Nevertheless, the early immigrants brought both interest in producing wine and the knowledge of how to grow grapes and make wine from Europe. While Idaho, Oregon and Washington each lay claim to have had the first grapes planted, the evidence for each is not definitive. Regardless of who came first, for Idaho what is known is that the first documented evidence of grapes being planted occurred in 1864 in the Lewiston-Clarkston Valley near the confluence of the Snake and Clearwater rivers (Wing, 1987, 1990). This first planting appears to have been Royal Muscadine from vine cuttings brought to the region by French-born Louis Delsol. By 1872 Delsol had bought his own land and imported more grape cuttings to establish his vineyard in the valley. Delsol was followed by another Frenchman, Robert Schleicher, who in 1872 bought some land along the Clearwater River roughly three miles east of Lewiston. It is thought that by 1900 he may have had somewhere between 80 and 130 acres of vineyards (Wing, 1990; Danehower, 2010). Following soon after Schleicher was German-born immigrant Jacob Schaefer who planted roughly 20 acres of grapes east of Lewiston along the Clearwater River. Schleicher appears to have been the most successful of these early Idaho winemakers, taking a number of gold medals for his wines at expositions in the US and a few world fairs. A newspaper article from the Lewiston Tribune dated October. 28, 1908 states that "…40 varieties of grapes are grown in Lewiston … Wine made from these took 18th prize among 800 of the world's competitors. These grapes have taken first prize over California in the last three great world's fairs." Schleicher's wines even caught the attention of the California Department of Agriculture's Napa viticulture agent, George C. Hussman, who deemed the wine to be "equal of anything made in Napa at the time" (Irvine and Clore, 1997). However, while some early success appears further north in Idaho, there appears to be little evidence for an early industry in the Snake River Valley until the 'wine revolution' of the 1960s (Adams, 1990; see below).

As with the other states, Prohibition was the downfall of the Idaho wine industry. Beginning in 1909 Idaho counties starting voting themselves dry and by 1916 statewide prohibition was in effect in Idaho. National prohibition, which followed state prohibition in 1919 and lasted until 1933, took its toll on wine regions all over the US. In the Pacific Northwest, Washington was the only state to develop a sound table grape and grapes for juice industry and was thus relatively unaffected by Prohibition, but its promise as a winegrowing region was effectively unrecognized for the better part of a century. For Idaho it took until 1970 before winegrapes were planted again in sufficient numbers, this time along the Snake River Valley in the southern part of the state where most of the state's wineries are located today (Figure 1). Three important events contributed to this rebirth of the

Idaho wine industry in 1970s. The first was the large scale development of major irrigation systems throughout the Snake River Valley plain, which started after 1950, making orchard and other broadacre crops such as winegrapes more viable (Baxevanis, 1992). The second occurred when the state legislature voted to remove its monopoly on liquor sales in 1969, bringing a five-fold increase in wine sales in ten years (Adams, 1990). The third event was the planting of winegrapes on the Symms Fruit Ranch in the Sunnyslope area in 1971 and the production of wine in 1976 Bill Broich, which ultimately led to the creation of what is now the Ste. Chapelle winery two years later (Baxevanis, 1992).

Historical statistics of grape acreage and production in Idaho is limited for many reasons. The early agricultural censuses (1840, 1850, and 1860) came prior to territory (1863) or statehood (1890) status, so no data was accumulated for Idaho and it was not until the 1900 agricultural census that Idaho produces enough to be listed outside the ‘other’ category of states (USDA, 2010). Furthermore, in many of the early censuses vineyards were either classified as “land in orchards” or given as the “number of farms’ growing grapes with no indication whether they were for table, juice, or wine. Often the data was also reported as the number of vines planted, with no indication to planting density or acreage. While the 1890 census is the first to have a section on ‘Viticulture’, Idaho was still listed in the ‘other’ category and it was not until the 1910 agricultural census that the first statistical glimpse of Idaho’s industry is noted (USDA, 2010). The 1910 census lists 1281 farms in Idaho reporting 604,277 pounds of grapes harvested that were valued at $18,814. Also in the 1910 census a separate entry shows that at least 25 farms were producing wine or grape juice with 3,452 gallons reported. From the 1910 through 1935 censuses the number of farms reporting growing grapes grew from 1,281 farms to 1,937 farms and the number of pounds harvested surpassed one million. Given that this was during Prohibition, the data would indicate that much of what was being grown in the state was either table or juice grapes, or possibly for sacrament or home wine production (USDA, 2010). From the 1940 to 1950 censuses the number of farms growing grapes continued to increase (from 1,937 to 3,041) however the pounds harvested dropped by over half. After 1950 the number of farms growing grapes dropped tremendously and it is not clear whether this was due to census reporting issues or the very cool climatic conditions during the 1950s. By some accounts there were as few as ten acres of vinifera winegrapes planted in 1967 (Baxevanis, 1992).

Starting in 1969 the USDA changed to reporting the number of actual vineyards and acreage planted and this may be the first accurate measure of the industry in Idaho. For the 1969 census 28 vineyards reported growing 158 acres of grapes and producing nearly 550,000 pounds of fruit (Table 3). For the USDA censuses from 1974 through 1997 both the number of vineyards and acreage reported for Idaho fluctuated tremendously. Again it is not known if this was due to under or over reporting in one census versus another or due to climate or disease losses or simply the economics of the small operations going in and out of business over the years. The reported numbers show an industry with a large number of vineyards covering a small amount of acreage, which likely indicates either many trial plantings or many home winemaking operations.

Specifically for the tree fruit censuses, which are more precise than the full censuses, in 1999 Idaho had 27 vineyards growing 684 acres of winegrapes. From 1999 to 2006, when the next tree fruit census occurred, Idaho saw an increase of 39 vineyards and acreage nearly doubling to 1271 acres (Table 3). In 1999 grapes made up 7% of the fruit acreage (4th largest fruit crop) in the state while in 2006 it grew to the 2nd largest fruit crop at 18% of the total acreage (apples were first for both censuses; USDA, 1999, 2006). In the tree fruit censuses, Canyon County has the greatest amount of acreage devoted to winegrapes in the state with 75 and 81% of the total acreage in 1999 and 2006, respectively. Of the 27 reporting vineyards in 1999 the sizes where equally distributed between small vineyards (< 5 acres) and larger vineyards, while for 2006 over 60% of the vineyards are less than 9 acres in size. Displaying the growth in the industry the 1999 data show that nearly 70% of the planted vines were greater than 13 years old (being planted prior to 1985), while the 2006 census shows that 50% of the vines where less than 10 years old (planted during 1996-2005). The 2006 census provided for the first time a partial variety summary with Riesling making up 30% of the total vines planted, Chardonnay 15%, Merlot 11%, Syrah 7%, and other all others 36%. A grower survey conducted by the Idaho Wine Commission reveals that the ‘others’ list is quite extensive with at least 35 different varieties being grown in the Snake River Valley AVA (Table 4). The survey also indicated that there were approximately 57 vineyards 1600 acres that together harvested 3227 tons and 43 wineries that produced 547,545 gallons or 230,297 cases in 2009. In addition, it was not until 1988 that Idaho appeared as its own category in TTB taxation reports (TTB, 2010). From these reports we know that Idaho produces just a fraction of a percent of the total wine produced in the US (California produces 90%), nearly 500,000 gallons or 200,000 cases of wine (TTB, 2010), ranking as the 14th largest state in 2010.

Table 3 – A summary of the reported number of vineyards and acres planted to winegrapes. Data from the standard USDA agricultural censuses and two Fruit Tree censuses (USDA, 1999; 2006; 2010).

Year	Vineyards	Acres	Notes
1969	28	158	
1974	19	262	Three vineyards made up 190 acres of the total
1978	107	139	
1982	108	250	
1987	85	729	
1992	68	482	
1997	60	279	
1999*	27	684	Grapes were 7% of all fruit acreage, 4th largest fruit crop
2002	131	930	
2006*	66	1271	Grapes were 18% of all fruit acreage, 2nd largest fruit crop
2007	174	1490	

* Note that 1999 and 2006 were Fruit Tree censuses conducted outside the normal USDA agricultural censuses.

Another more recent event that has contributed to the continued development of the Idaho wine industry was the creation of Idaho's first American Viticulture Area (AVA), the Snake River Valley (Figure 1). The petition to the TTB was filed by the growers in the Snake River Valley, the Idaho Grape Growers and Wine Producers Commission, and the Idaho Department of Commerce and Labor and approved in April 2007 (Code of Federal Regulations, 2007). The Snake River Valley AVA is located in southwestern Idaho and east-central Oregon encompassing land in twelve counties in Idaho and two in Oregon and features the largest density of vineyards and wineries in Idaho. The area encompasses more than 8,000 square miles of land at latitudes comparable to many of the famous wine regions around the world (43°- 46°). The boundary for the Snake River Valley AVA is derived from the contour level of the Pliocene Lake Idaho (1050 m or 3444 ft above sea level) which formed more than four million years ago (see the next section for more information). For wines to have the Snake River Valley AVA on the label, at least 85% of the grapes used for production must be grown within the AVA.

Table 4 – A summary of the reported 'other' varieties being grown in Idaho. Data from an Idaho Wine Commission grower survey conducted in 2009.

Red Varieties	White Varieties
Barbera	Chardonnay
Cabernet Franc	Gewurztraminer
Cabernet Sauvignon	Muscat Canelli
Carmenère	Pinot Gris
Cinsault	Riesling
Counoise	Roussanne
Grenache	Sauvignon Blanc
Lemberger	Semillon
Malbec	Viognier
Merlot	White Pinot Noir
Mourvèdre	
Nebbiolo	
Petit Syrah	
Petit Verdot	
Pinot Noir	
Primitivo	
Rubired	
Sangiovese	
Souzão	
Star Garnet	
Syrah	
Tempranillo	
Tinta Cão	
Touriga Nacional	
Zinfandel	

The first economic analysis for the winegrape industry in Idaho was done by Michalson (1975) and indicated that a grape industry could contribute to the profitability of Idaho agriculture, depending on the variety of grapes grown and their adaptation to Idaho climatic conditions. Further work on economic feasibility by Woodhall et al. (2002) found that growing winegrapes in southwestern Idaho could be a viable diversification crop when other fruit crops become uneconomical due to low prices and/or high costs of production. Furthermore, a recent economic impact study (Idaho Business Review, 2009) found that the Idaho wine industry contributed $73 million to the state's economy in 2008, with $52 million in revenue and $19 million in wages from 625 full-time equivalent jobs.

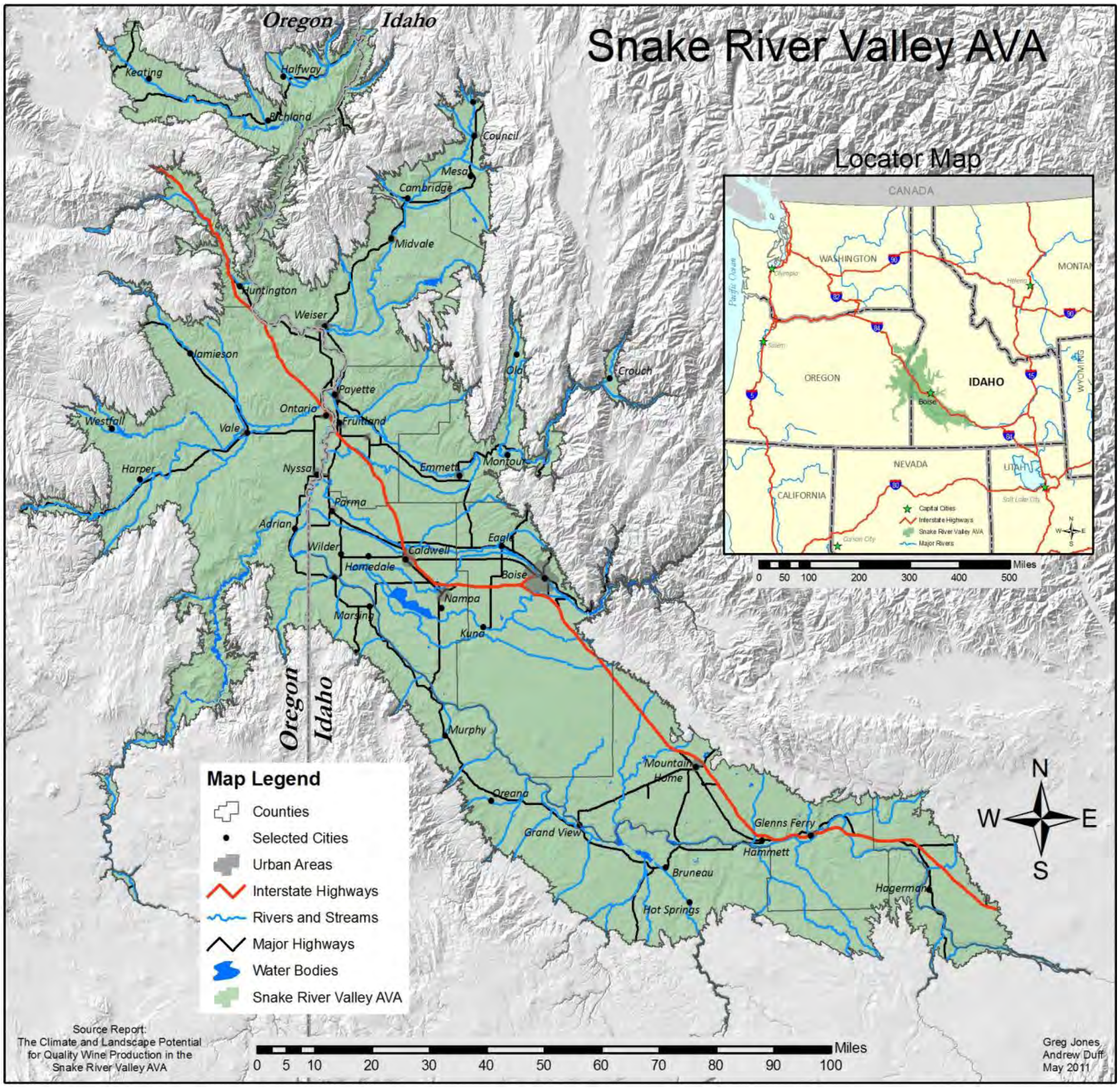

Figure 1 – The location of the Snake River Valley American Viticultural Area (AVA). Note that the boundary shown above and used in this analysis was derived from the 1050 m (3444 ft) contour (Gillerman et al. 2006) and is approximately that which was approved by the TTB (2007). Slight differences in the boundary will occur due to the source of the elevation data, its resolution, and the datum and coordinate systems used.

General Overview of Physiography, Geology, Soil, and Ecology

The Snake River Valley AVA encompasses 8,263 square miles (nearly 5.3 million acres) over the Western Snake River Plain of Idaho and Oregon (Figure 1). The area has a mean elevation of 2880 ft and ranges from a low of nearly 1800 ft along the Snake River in the northern most point of the AVA to a high of nearly 4900 ft in a few mountain tops west of Lake Owyhee, NE of Huntington, and NE of Halfway (Jones et al. 2010).

One of the most common and useful means to categorize the landscapes of the United States is through the dominant ecoregion (Omernik et al. 2000). Ecoregions denote and describe regions with general similarities in the type, quality, and quantity of environmental resources which in turn provide a means for research, assessment, management, and monitoring of ecosystems by federal, state and local agencies. Ecoregions for the United States have been developed based upon the spatial patterns and composition of biotic and abiotic phenomena including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. These ecoregions vary from the coarse, national scale Level I (15 regions) to the finer, regional scale Level IV regions (hundreds of regions) (USEPA, 2000).

Idaho and Oregon are both ecologically diverse states. In Idaho there are ten Level III ecoregions (Figure 2) and 71 Level IV ecoregions with many overlapping into ecologically similar parts of adjacent states (McGrath et al. 2002). Idaho is largely made up of semiarid shrub- and grass-covered plains, irrigated agricultural valleys, volcanic plateaus, forested mountains, woodland- and shrubland-covered hills, glaciated peaks, lava fields, and wetlands. Oregon has nine Level III ecoregions (Figure 2) and 65 Level IV ecoregions with the west side of the state having a marine-influenced climate with generally plentiful precipitation 2-3 seasons during the year. In contrast, eastern Oregon lies in the rain shadow of the Cascades and is much drier. The result is a strong ecoregion gradient with varied areas of forested mountains, glaciated peaks, shrub- and grass-covered plains, agricultural valleys, beaches, desert playas, and wetlands (Thorson et al. 2003). Sharing a portion of eastern Oregon and western Idaho, the Snake River Valley AVA encompasses four of the Level III ecoregions in the United States (Figure 2). These include portions of the Blue Mountains, the Snake River Plain, the Idaho Batholith, and the Northern Basin and Range ecoregions. A total of sixteen Level IV ecoregions make up the Snake River Valley AVA (Figure 3) and are described below and given in more detail in Appendix Table 1.

Figure 2 – Level III ecoregions of the conterminous United States. Map Source USEPA, 2000.

The Blue Mountain ecoregion is a complex of mountain ranges that are lower and more open than the Cascades and Northern Rockies. The Blue Mountains are mostly volcanic in origin (similar to the Cascades) however some zones within the ecoregion (the Wallowa and Elkhorn Mountains) are composed of granitic intrusives, deep sea sediments, and metamorphosed rocks. The Blue Mountains are confined to the northern portion of the Snake River Valley AVA consisting of five Level IV ecoregions (Figure 3). These areas are mostly isolated in the higher mountain valleys on either side of the Snake River in Oregon and Idaho (McGrath et al. 2002; Thorson et al. 2003). Of the five Blue Mountain ecoregions in the AVA, the Continental Zone Foothills (11i in Figure 3) makes up the majority of the land. The Continental Zone Foothills are unglaciated foothills made up mostly of Quaternary colluvium from tertiary basalts with some isolated greywacke and granitics. Soil orders range from mollisols, to aridisoils, to vertisols with numerous soil series common to the region (Barker et al. 1983). The dominant vegetation pattern in the Continental Zone Foothills is of a shrub and grass covered steppe with much of the land used for rangelands or in native wildlife habitat (Appendix Table 1). The other four Blue Mountain ecoregions in the AVA make up a very small area up valley extensions (see Appendix Table 1 for a complete overview the physiography, geology, soils, and plant communities for each region).

The dominant physiographic region in the AVA is the Snake River Plain, which consists of six Level IV ecoregions (Figure 3). The Snake River Plain is a geologic feature located primarily within the state of Idaho, stretching roughly 400 miles from Wyoming to the Oregon border in a wide, relatively flat bow-shaped depression, covering about a quarter of Idaho (McGrath et al. 2002). The Snake River Plain was created by the combined forces of the North American tectonic plate moving over a volcanic hotspot, which now lies underneath Yellowstone National Park in Wyoming, and gigantic floods from the last glacial period (Alt and Hyndman, 1989). The biggest of these floods occurred roughly 14500 years ago when Lake Bonneville (in present day Utah) was at its greatest size and spilled over into a tributary of the Snake River in a catastrophic event known as the Bonneville Flood (Maley, 1983; Gillerman et al. 2006). Combined with the Missoula Floods further north in Washington, Idaho, and Montana, these gigantic glacial-retreat flooding episodes carved out many topographical features including various canyons, ridges, and falls along the Snake and Columbia rivers. While the scouring of the canyons was immense, just as important to the region was the large amount of sediments that were deposited along the river which produced the rich agriculture soils found over the Snake River Plain today (Barker et al. 1983). Furthermore, the volcanic hotspot deposited basalt layers that have high hydraulic conductivity and lead to the formation of the Snake River Aquifer, one of the most productive aquifers in the United States. Today the Snake River is the largest tributary of the Columbia River, nearly 1100 miles long, and the thirteenth largest river in the United States. The river's watershed is the tenth largest in the United States, draining an area of approximately 108,000 square miles, over portions of six states: Wyoming, Idaho, Oregon, Utah, Nevada, and Washington, with the largest portion in Idaho.

Today the plains and low hills of the Snake River Plain ecoregion are considered part of the dry, inter-mountain west region. This region is considerably lower in elevation and less rugged than the surrounding Cascades and Northern Rockies ecoregions. Due to the underlying aquifer, irrigation water is plentiful in many areas and many of the alluvial valleys along the Snake River are in agriculture, principally growing sugar beets, potatoes, alfalfa, small grains, and vegetables. Areas not in irrigated agriculture are typically covered by sagebrush–grassland and are often used for cattle grazing or in open landscapes (McGrath et al. 2002). The Treasure Valley (12a) Level IV ecoregion covers the central portion of the AVA from Boise west across the Oregon border and up along the Snake River and two of its tributaries the Payette and Malheur rivers (Figure 3). Further southeast there is a smaller area of the Treasure Valley ecoregion that starts northwest of Grand View and extends along the Snake River to the Bruneau Valley. The Treasure Valley ecoregion is typically underlain by Quaternary alluvium, loess, lacustrine, and alluvial fan deposits (Appendix Table 1). Due to the xeric conditions over the area, the soils have an arid regime and originally supported sagebrush/grass plant assemblages before much of the valley was converted to agriculture. Canals and diversions supply water to pastureland and cropland as well as municipalities.

Other Snake River Plain ecoregions include the Semiarid Foothills (12f) which are found in the northeast section of the AVA from just south of Midvale and north to Council, Idaho (Figure 3). This ecoregion is higher in elevation and more rugged than the Treasure Valley ecoregion and has

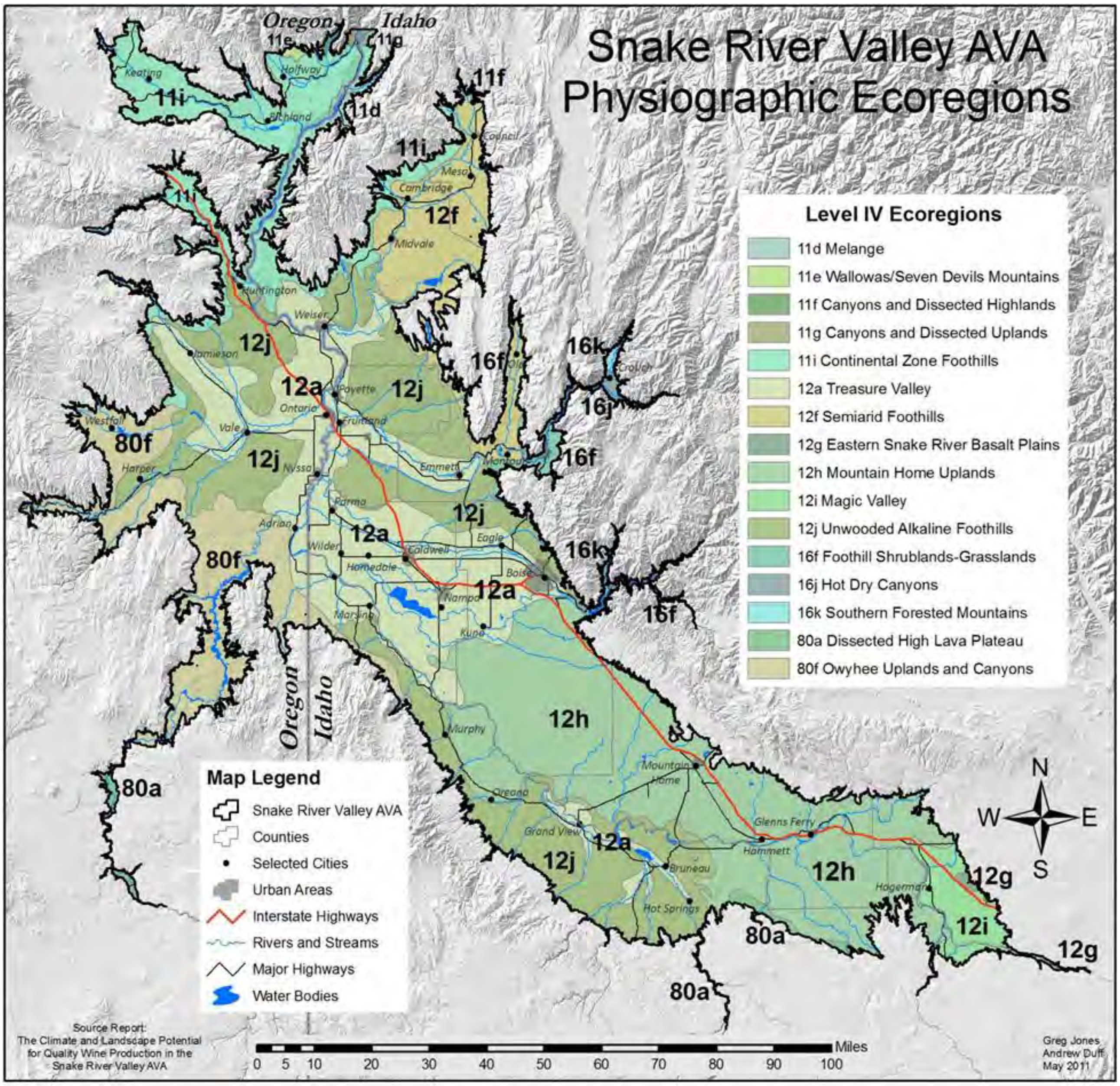

Figure 3 – Level IV ecoregions in the Snake River Valley AVA. Data mapped form USEPA (2000) with the full descriptions given in Appendix Table 1.

few perennial streams and typically shallower, clayey soils (Appendix Table 1). The Eastern Snake River Basalt Plains ecoregion (12g) is isolated to the far southeastern portion of the AVA (Figure 3) and typically has shallow, stony soils that are considered unsuitable for cultivation of most crops (McGrath et al. 2002). The Mountain Home Uplands ecoregion (12h) encompasses a large area of the Snake River Plain from Boise southwest to Murphy and southeast to Hagerman. This ecoregion is also arid and mostly shrub- and grass-covered that is largely used for rangeland. Some areas of the ecoregion, at lower elevations along the Snake River east of Murphy and from Hammett to Hagerman, are irrigated and used for agriculture. From Hagerman southeast toward Twin Falls is the Magic Valley ecoregion (12i) which is a broad valley dissected by numerous irrigation canals that support many field crops and dairy and livestock farms (Figure 3). At elevations above the Treasure Valley ecoregion are the Unwooded Alkaline Foothills ecoregion (12j). These areas are more rugged than the Treasure Valley landscapes containing rolling foothills, benches, alluvial fans, and badlands that are commonly underlain by alkaline lake bed deposits. More typically in rangeland or open wildlife habitat, these areas can support agriculture where enough water is available for irrigation (Appendix Table 1).

Isolated to a few valleys north and east of Emmett and Boise are areas in the AVA associated with the Idaho Batholith ecoregions (Figure 3). Overall these ecoregions are more mountainous, were partially glaciated, and typically deeply dissected landscapes that are underlain by granitic rocks. Northeast of Emmett are valley extensions that follow the south and middle forks of the Payette River and Squaw Creek (Ola Valley) that consist of the Foothill Shrublands-Grasslands (16f), Hot Dry Canyons (16j) and Southern Forested Mountains (16k) Level IV ecoregions. South and east up the Boise River and a few of its tributaries are landscapes in the Foothill Shrublands-Grasslands (16f) and Southern Forested Mountains (16k) ecoregions. Along each of the river valley extensions the landscapes are typically in shrubs and grasses with forested areas on northern slopes and at higher elevations. These areas do not support large scale agriculture usually due to the droughty and limited fertility soils that are derived from the granitic parent material (Appendix Table 1).

Reaching into the southern portion of the Snake River Valley AVA are areas associated with the Northern Basin and Range ecoregion (Figure 3). This ecoregion is overall higher, cooler, and slightly wetter than the Snake River Plain ecoregions and contains dissected lava plains, rolling hills, alluvial fans, valleys, and scattered mountainous areas (Thorson et al. 2003). Within the AVA the small areas of the Dissected High Lava Plateau ecoregion (80a) can be found in and along the Bruneau Canyon and over the upland of the Bruneau Desert. Another zone of this ecoregion can be found as the Owyhee River extends south and west into Oregon (Figure 3). Making up a significant portion of the west, southwest portion of the AVA extending along the Owyhee Mountains in Idaho and Oregon, is the Owyhee Uplands and Canyons ecoregion (80f). This ecoregion is considered sagebrush steppe and contains deep river canyons, barren lava fields, and badlands (Appendix Table 1). Native shrub and grasses are common, but juniper woodlands can be found on uplands throughout the region. Due to less suitable soils than in the Snake River Plain, agriculture is isolated to zones where water is available and soils are more conducive to crops (Thorson et al. 2003).

Climatic Environment

At the broadest scale the weather and climate of the Snake River Valley AVA is driven by its latitude and its location in the westerly winds and the associated seasonality of storms coming off the Pacific. However, the strongest regional influence is the distance from the Pacific Ocean and the rain shadow effects of the mountains to the west, which produces a moderately strong continentality effect. To further characterize and depict the spatial climate characteristics in the Snake River Valley AVA, the information below and the terroir zoning model both utilize a climate dataset called PRISM (Parameter-elevation Relationships on Independent Slopes Model) that is the official spatial climate data set of the United States Department of Agriculture (Daly et al. 2008). The 1971-2000 climate normals data are created as 15 arc-second (~400 m, 1312 ft) grids through an interpolation method that reflects the current state of knowledge of spatial climate patterns in the United States. In general, PRISM calculates a climate-elevation regression for each digital elevation model (DEM) grid cell, and stations entering the regression are assigned weights based primarily on the physiographic similarity of the station to the grid cell. PRISM takes into account the location, elevation, coastal proximity, topographic facet orientation (aspect), vertical atmospheric layer, topographic position, and orographic effectiveness of the terrain. The PRISM grids are constructed from a comprehensive collection of stations from many networks, including the National Weather

Service Cooperative Network, USDA Snow Telemetry, US Forest Service Remote Automatic Weather Stations, local networks, snow courses, and others (16615 precipitation sites and over 11500 temperature sites were used in the United States). In addition to the dense station network, the PRISM data set underwent a comprehensive peer review procedure that incorporated local knowledge and data into the development process. Furthermore, PRISM has been validated using remote vineyard locations (Jones unpublished data), successfully applied in viticulture zoning studies (Jones et al. 2004; Jones et al. 2006), and used by Jones et al. (2010) to characterize the climate of each of 135 AVAs in the western United States.

The PRISM climate data used in this report include monthly precipitation, maximum and minimum temperatures, and the median dates of the first fall and last spring frosts. Monthly precipitation grids are summarized for annual, growing season (April-October), bloom (May-June), and ripening (September-October) periods. Annual precipitation over the entire Snake River Valley AVA averages 12.5 inches with a minimum of 6.6 inches and a maximum of 34.1 inches (Figure 4). The driest zone is located in the south-central portion of the AVA running from roughly Oreana to Hot Springs (Figure 4). The wettest zone is in the northern extensions of the AVA into higher elevation zones. Given the dry summer regional climate structure, the Snake River Valley AVA growing season precipitation (April through October) is quite low, averaging 5.4 inches over the entire AVA, but with the majority of the central to southern part of the AVA experiencing 4 inches or less (Figure 5). An examination of precipitation amounts during the critical bloom and berry set stages (May-June) finds less than an inch of rainfall on average over the AVA (Figure 6). During ripening (September-October), when moisture can bring disease pressure, the region also experiences very little rainfall, averaging less than 1.5 inches over the vast majority of the AVA (Figure 7).

As described in the section on ‘Climate Requirements” above, heat accumulation is one of the more common measures used to assess viticulture-climate suitability. To characterize heat accumulation over the Snake River Valley AVA monthly maximum and minimum temperature grids from PRISM are processed into growing degree days (GDD) from April to October using a base of 50°F with no upper temperature cut off. Climate-maturity groupings for standard Winkler Regions classes (Table 1) and updates to the lower Region I and upper limit of Region V classes found by Jones et al. (2010) and Hall and Jones (2010) are discussed here. For the 1971-2000 climate normals, GDD averages 2392 over the entire AVA (Region Ib), with a minimum of 1500-1600 in the upper elevations in Oregon (NW portion of the AVA) and upper elevations in the river valleys to the north and east in Idaho, to a maximum of 3100-3300 (Region III) along the Snake River to the east of the town of Murphy (Figure 8). Compared to other AVAs in the western US, the Snake River Valley AVA is relatively cool, ranking 115th out of 135 AVAs in median GDD with similar regions being the Yakima Valley, Santa Rita Hills, Red Mountain, and Russian River Valley (Jones et al. 2010). However, examining the maximum GDD levels in the Snake River Valley finds that it ranks 47th out of 135 AVAs with similar regions being Dry Creek Valley, Potter Valley, Redwood Valley, Howell Mountain, and Chalk Hill.

However, it is important to note that the 1971-2000 climate normals include a very cold period from 1971 to the early 1980s and using a more recent nine year period from 2000-2008 reveals a different situation (Figure 9). Overall the region was warmer during 2000-2008 with no areas below 1500 GDD and some areas reaching into Region IV. Changes in area between the two time periods (Figures 8 and 9) show a large reduction in the area in Regions Ia and Ib with large increases in Region II and III (Table 5). The same area along the Snake River east of Murphy even exhibited Region V GDD values during 2000-2008.

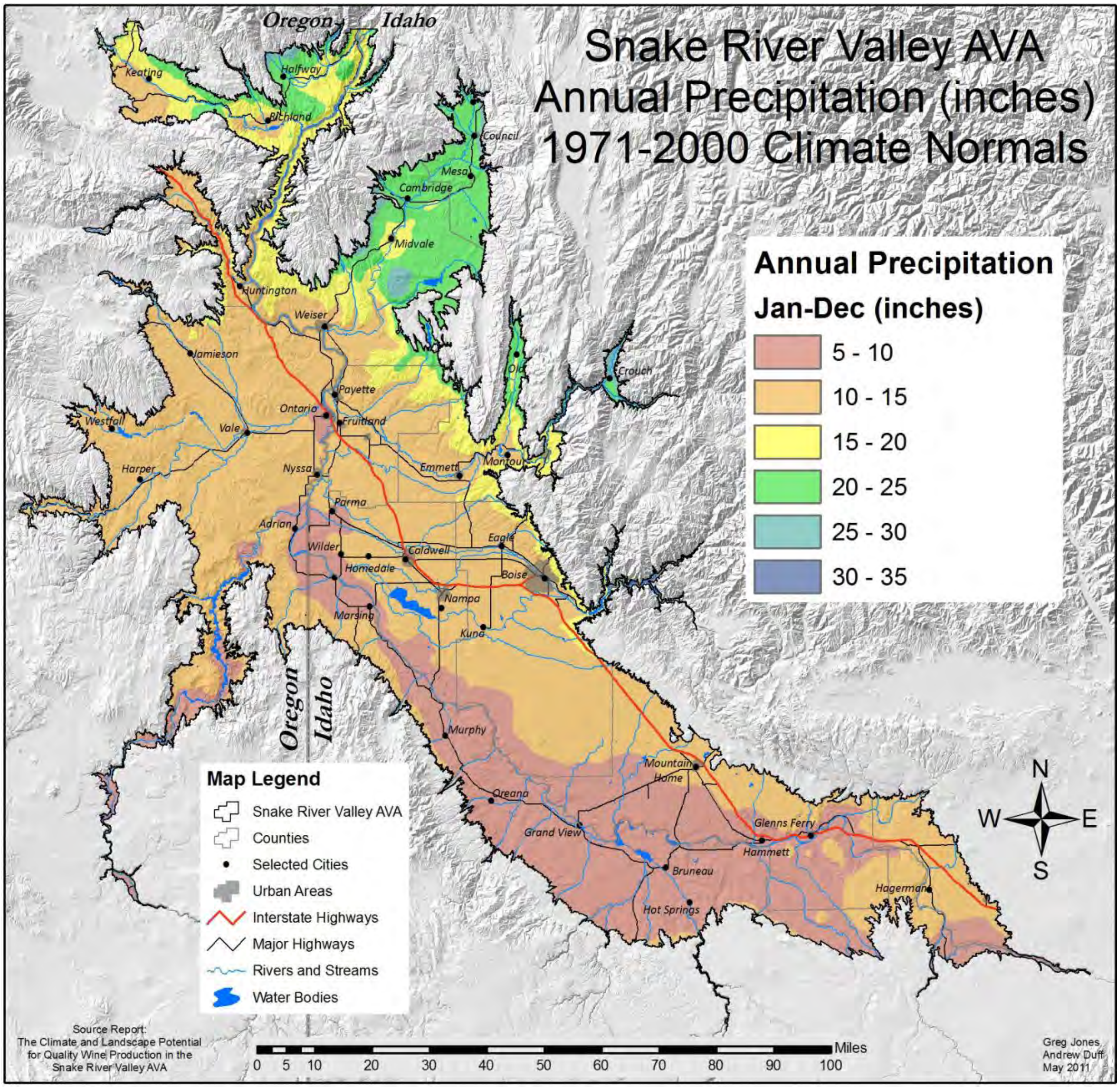

Figure 4 – The Snake River Valley AVA annual precipitation (1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

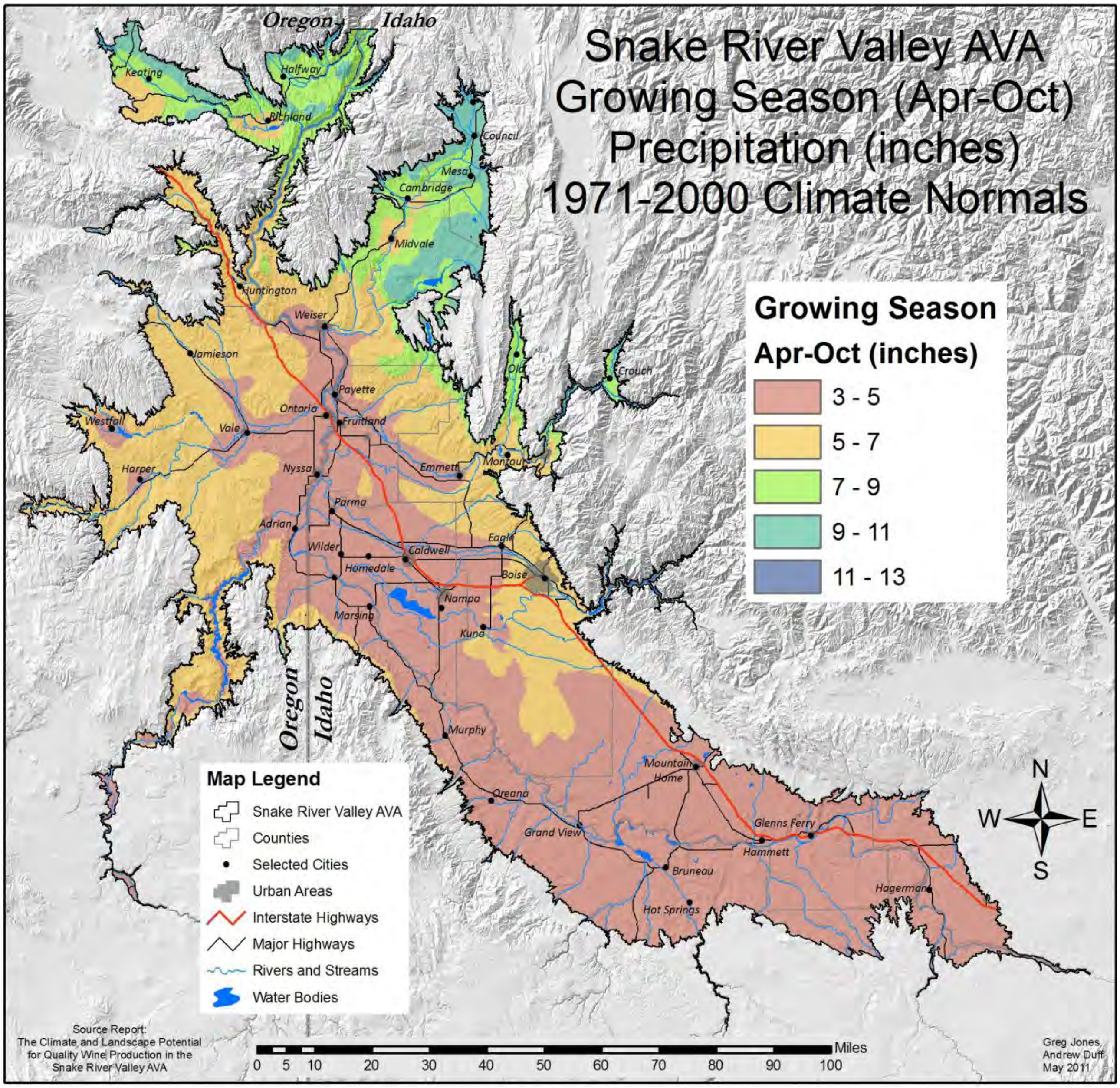

Figure 5 – The Snake River Valley AVA growing season (April-October) precipitation (1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

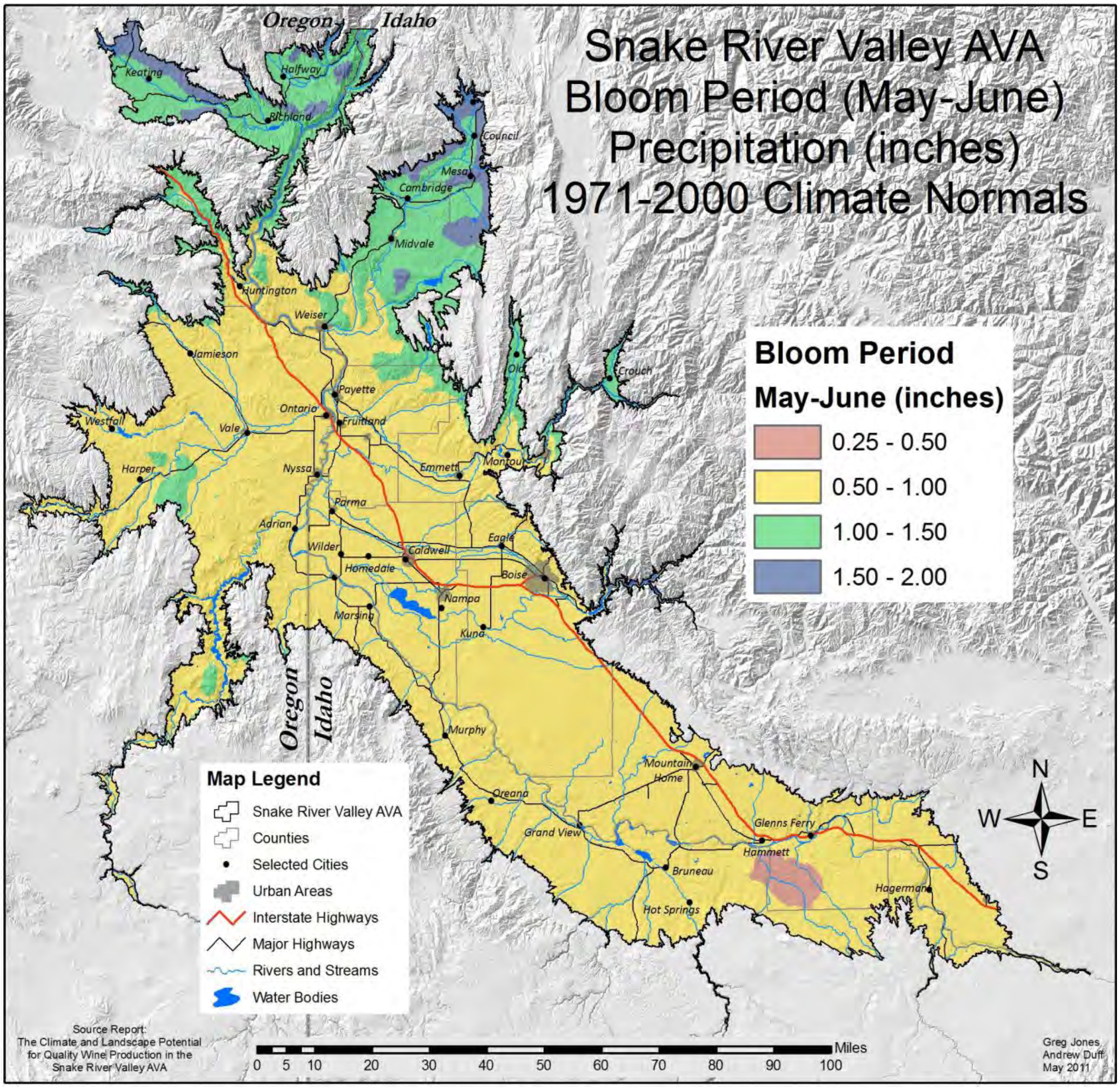

Figure 6 – The Snake River Valley AVA bloom period (May-June) precipitation (1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

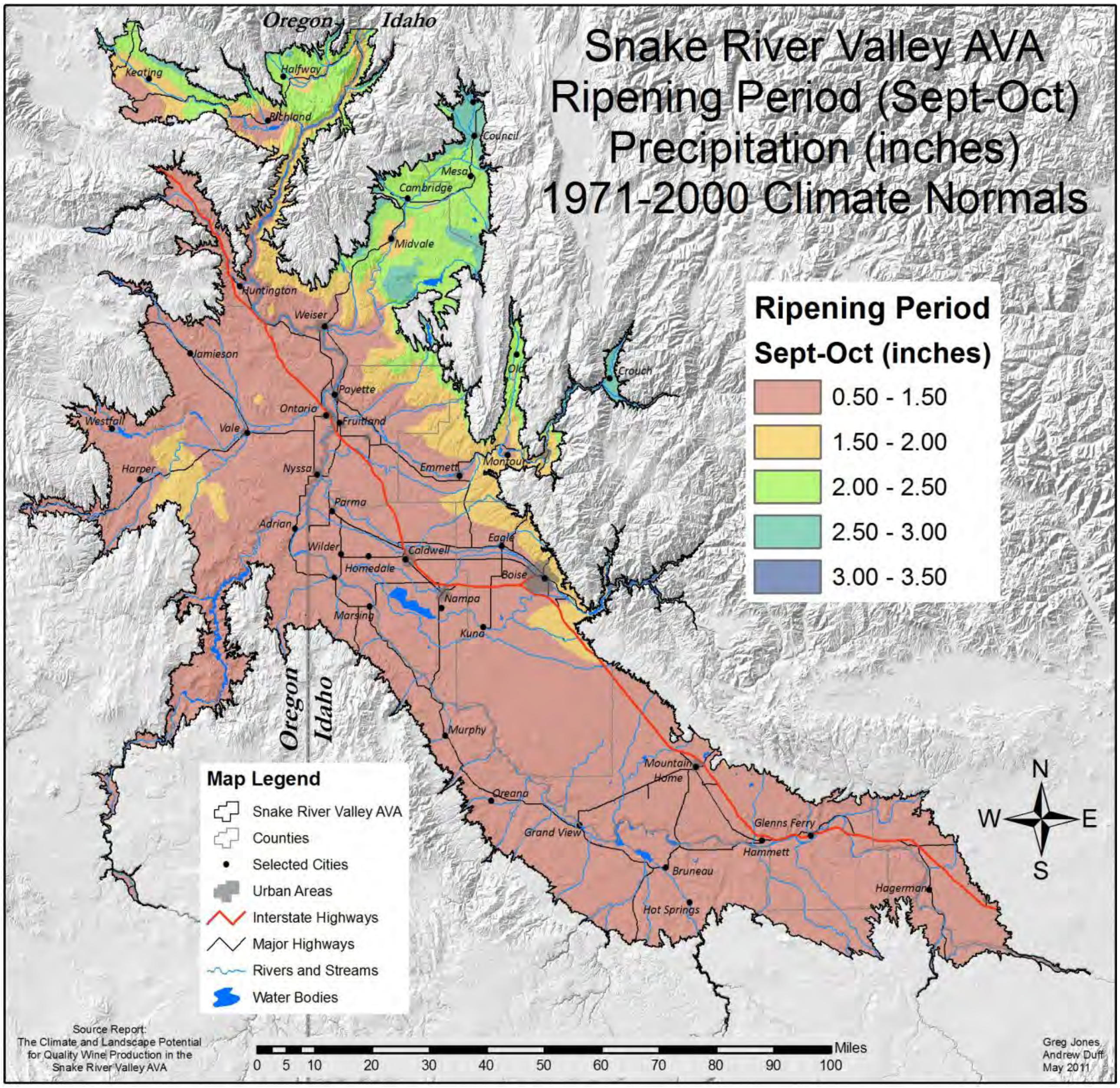

Figure 7 – The Snake River Valley AVA ripening period (September-October) precipitation (1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

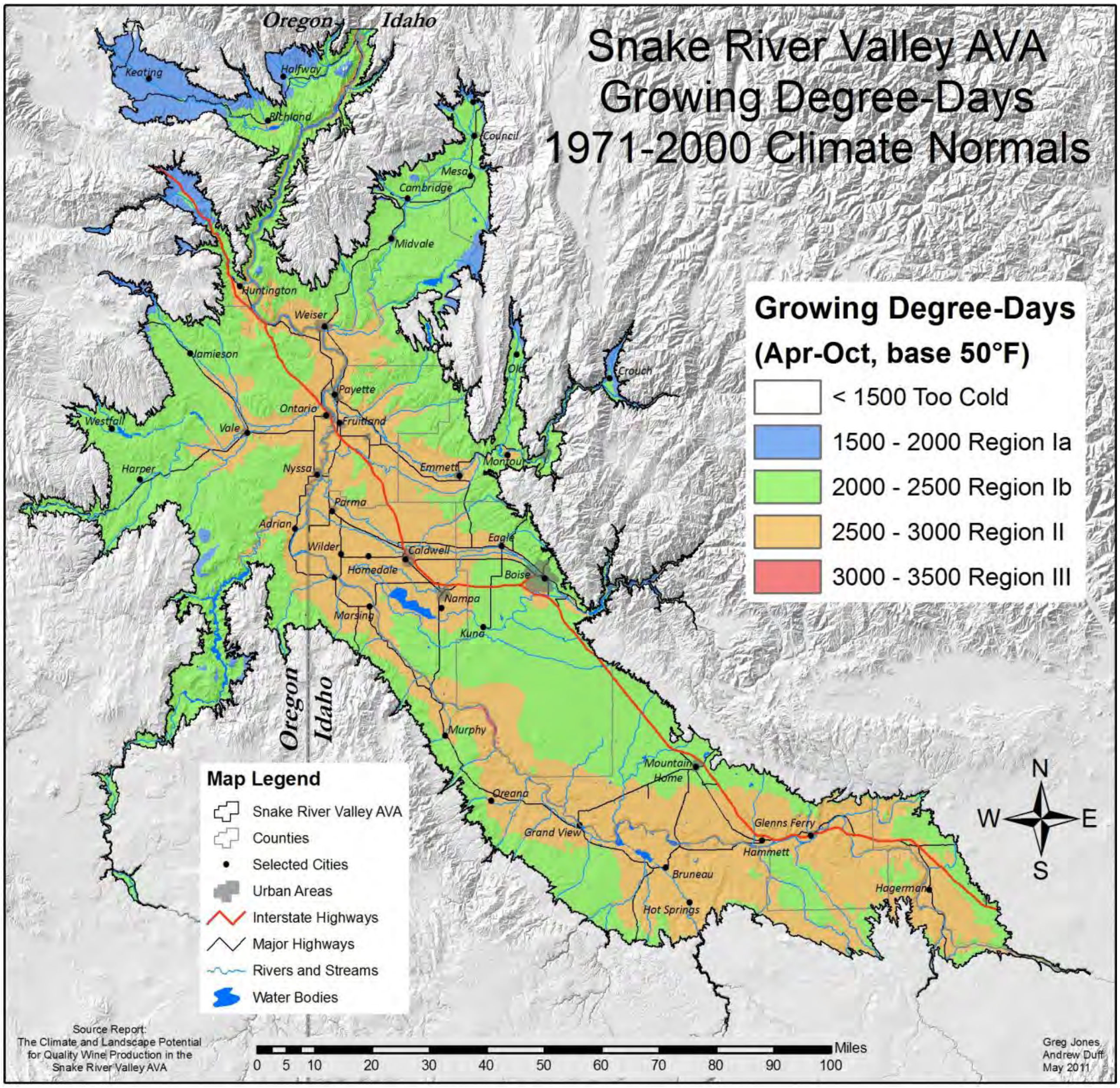

Figure 8 – The Snake River Valley AVA 1971-2000 average growing degree-days (Apr-Oct, base 50°F and no upper limit; 1971-2000 Climate Normals). Note that the class ranges mapped here corresponds to traditional Winkler Regions (Winkler et al. 1974) and updates to the lower Region I class found by Jones et al. (2010) and Hall and Jones (2010). (Data Source: Daly et al. 2001).

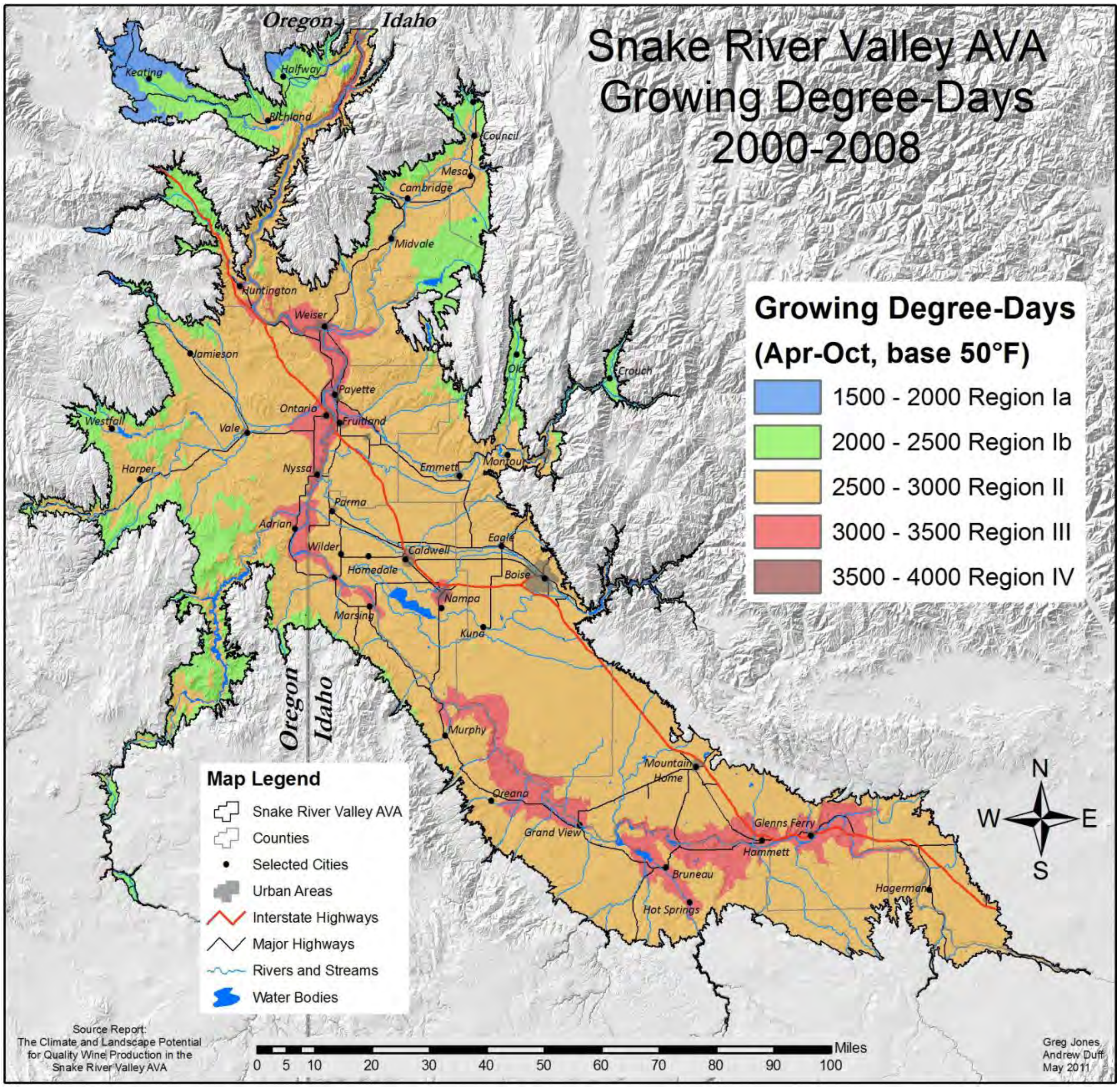

Figure 9 – The Snake River Valley AVA 2000-2008 average growing degree-days (Apr-Oct, base 50°F and no upper limit; 1971-2000 Climate Normals). Class ranges are as mapped in Figure 8. (Data Source: Daly et al. 2001).

Table 5 – Amount of area in the Snake River Valley AVA for each of the Winkler Regions depicted in the map in Figure 8 (1971-2000 period) and Figure 9 (2000-2008 period).

Suitability	Winkler Region*	1971-2000 Area (ha)	2000-2008 Area (ha)	Change in Area (ha)
Very Cool Suitability	Region Ia	119,084	35,669	-83,415
Cool Suitability	Region Ib	1,174,226	312,752	-861,474
Intermediate Suitability	Region II	869,954	1,595,081	725,127
Warm Suitability	Region III	1,552	220,179	218,627
Very Warm Suitability	Region IV	0	823	823

Another comparable measure of climate suitability is the maturity groupings based upon simple average growing season temperatures (Figure 10). Average growing season temperatures (April through October) are functional identical to GDD (Jones et al. 2010), but are generally easier to calculate and have been related to the potential of varieties to mature in climates worldwide (Jones, 2006). Values of growing season average temperatures over the Snake River Valley AVA average 61.1°F, ranging from 55.4°F to 65.5°F (no map shown, same general pattern as Figures 8 and 9) with over 95% of the region falling between 57.5°F and 63.0°F (green shaded area in Figure 10). Approximately 2% of the AVA is between 55.4°F and 57.5°F (cool) and 3% of the AVA is from 63.0°F and 65.5°F (warm). The area would therefore be classified as a largely Intermediate climate, with the ability to ripen a range of cool climate varieties (e.g., Riesling, Chardonnay, etc.) on the cooler sites, to ripening warmer climate varieties such as Tempranillo, Merlot, Syrah, etc. on the warmer sites.

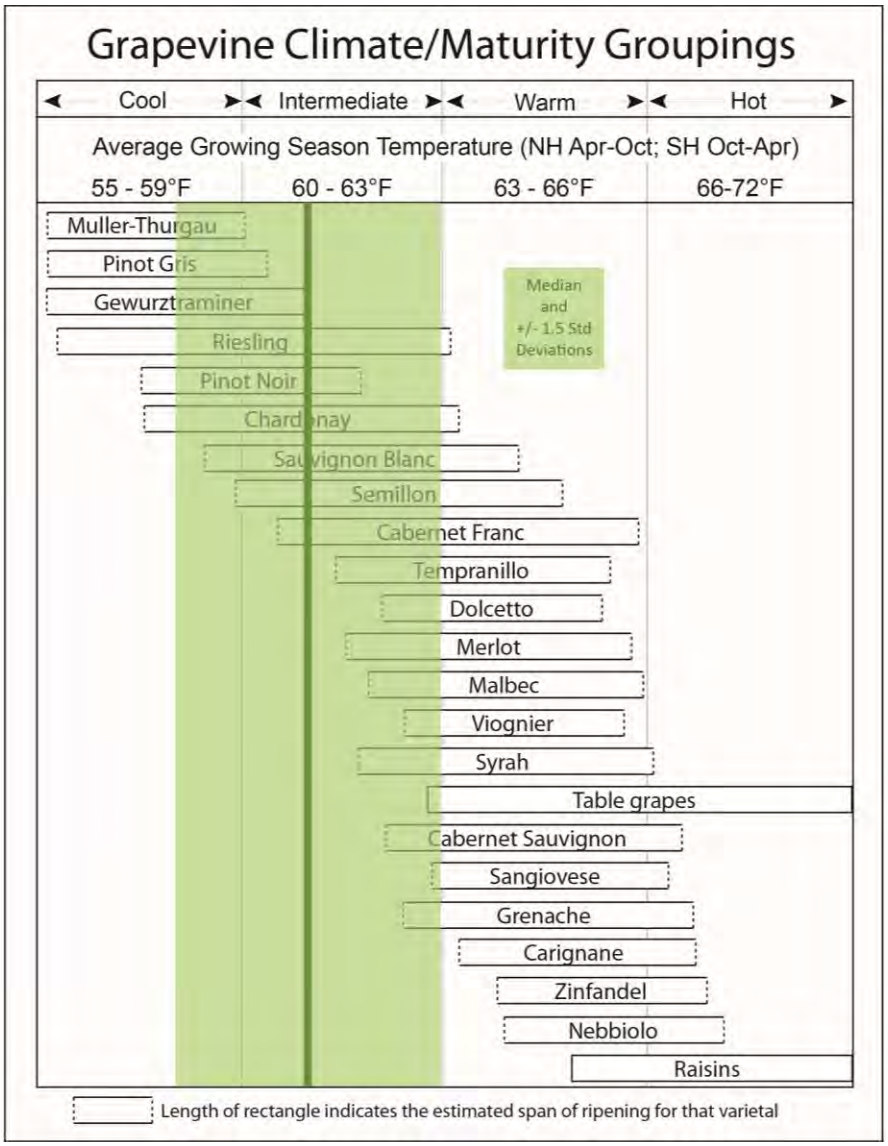

Figure 10 – Climate-maturity groupings based upon growing season average temperatures (Jones, 2006). The vertical dark green bar is the median value for the Snake River Valley while the green shaded area is the predominant climate suitability in the region (+/- 1.5 standard deviations about the median).

Given the continental location, relatively high elevations, and proximity to cold air moving out of Canada, both winter freeze severity and spring/fall frost are important aspects of the Snake River Valley AVA. The PRISM data do not have a winter extreme grid and therefore this aspect will be discussed later in a summary of climate stations in the region. However, the PRISM data does cover the median date of the last spring frost and the median date of the first fall frost based upon the 1971-2000 Climate Normals. Examining the median last spring frost date for the region shows that region has areas of very late spring frost (later than May 28th) over most of the northern part of the AVA and into the river extensions at higher elevations (Figure 11). Early last spring frost dates prior to April 24th are limited to areas along the Snake River within the central part of the AVA and along the Idaho/Oregon border. Given that Shellie (2007) found a median bud break date of April 19th over numerous white and red varieties at Parma, the map in Figure 11 would indicate that much of the region has moderate spring frost risk for winegrapes, however warmer sites on sloping land should reduce this risk. The median first fall frost map also indicates moderate risk with many areas experiencing a frost prior to October 1st (Figure 12). These areas are typically at higher elevations, along the upper river drainages, and across most of the northern portion of the AVA. Areas that experience a median first fall frost after the middle of October include a similar zone along the Snake River from the south-central portion of the AVA all the way up along the Idaho/Oregon border (Figure 12).

The number of days between the last spring and first fall frosts is the median frost-free period, which is often considered the length of the growing season (Jones and Hellman, 2003). The PRISM frost date grids are subtracted to produce a median frost-free period grid and classed into seven day groups (Figure 13). The Snake River Valley AVA is mostly characterized by areas with a very short frost-free period (< 148 days). Area along the Snake River, from the south-central portion of the AVA to the Oregon border near Payette, to the east of the Snake River toward Emmett, Caldwell, and Nampa have the longest frost-free days of over 168 days (Figure 13). Other isolated areas with longer frost-free periods include areas to the east of Huntington and Halfway, Oregon. Shellie (2007) found that numerous varieties trialed at the Parma research station needed an average of 157-163 days for maturation. Figure 13 would therefore indicate that much of the Snake River Valley on average has too short of growing seasons to fully mature many varieties. Again, the results point to maximizing site characteristics in order to minimize frost and provide a longer growing season that can consistently ripen the majority of the suitable varieties.

While the spatial summary of climate over the Snake River Valley AVA above gives an overall characterization of the region, a station summary is worth examining to better understand climate parameters not available in the PRISM data. Furthermore, the 1981-2010 Climate Normals for the United States has been released but have not been updated in the PRISM data model. Numerous climate stations (>100) can be found within the AVA, however only a smaller sub-set have consistently long term records and are available in the 1981-2010 Climate Normals (20 stations in Idaho and 9 in Oregon; Table 6). These stations represent a broad geographic and elevational range over the AVA. For annual precipitation these stations all show the area's dominant characteristic of a wet winter and dry summer regime (Figure 14) with a 29 station average of 12.57 inches for the 1981-2010 Climate Normals. However, these stations range nearly 20 inches with a low of 7.15 inches for Grandview, Idaho and a high of 26.52 inches for Garden Valley, Idaho (Table 6).

For annual average temperatures the stations range from a low of 46.1°F for Ironside, Oregon to 54.7°F for Bruneau, Idaho. For average growing season temperatures the stations average 62.3°F and range from a low of 57.6°F for Ironside, Oregon to a high of 65.9°F for Swan Falls, Idaho (Table 6). Growing degree-days over the locations average 2661 and range from a low of 1850 for Ironside, Oregon to a high of 3413 for Swan Falls, Idaho.

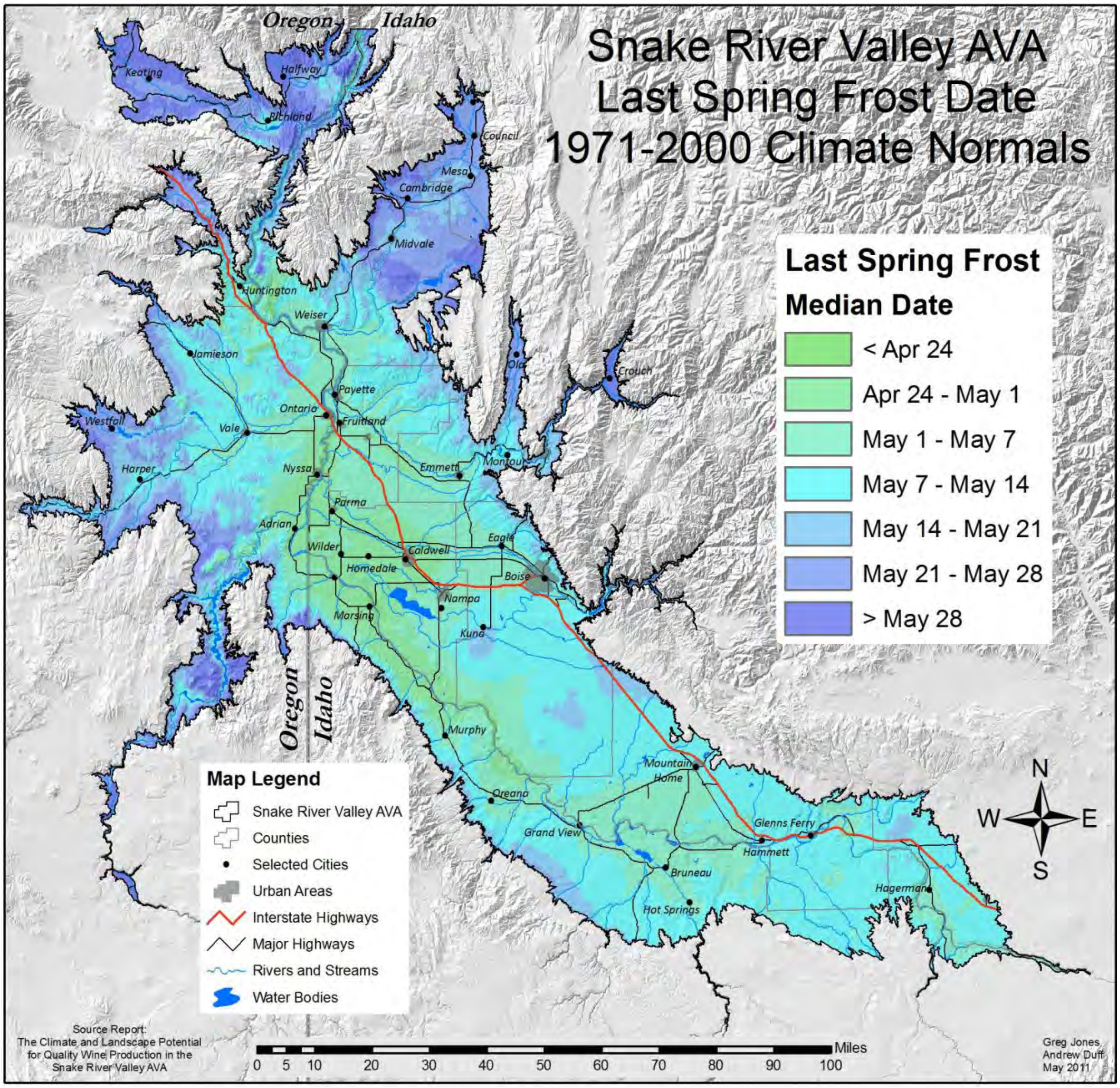

Figure 11 – The Snake River Valley AVA median date of the last spring frost (32°F; 1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

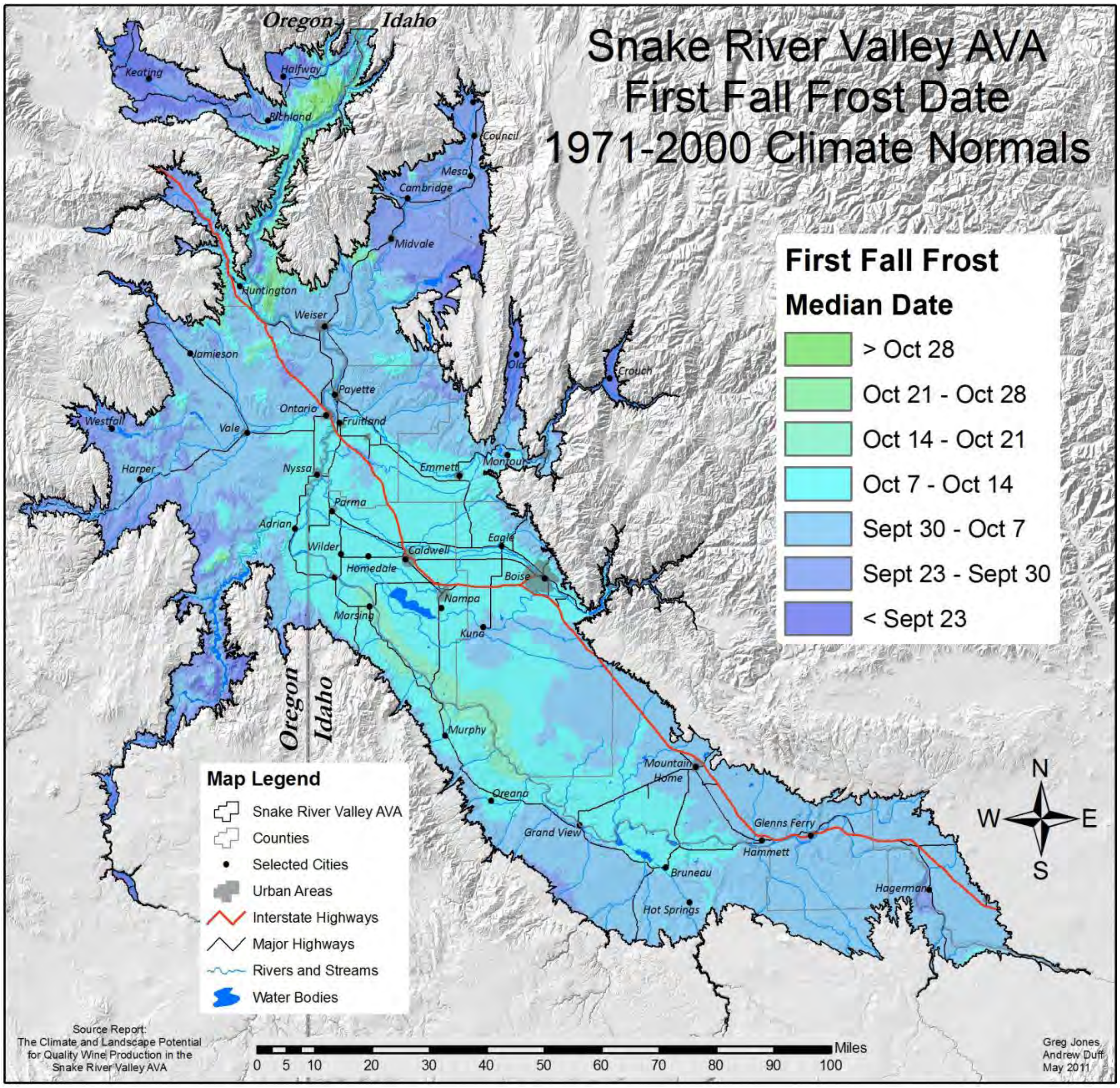

Figure 12 – The Snake River Valley AVA median date of the first fall frost (32°F; 1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

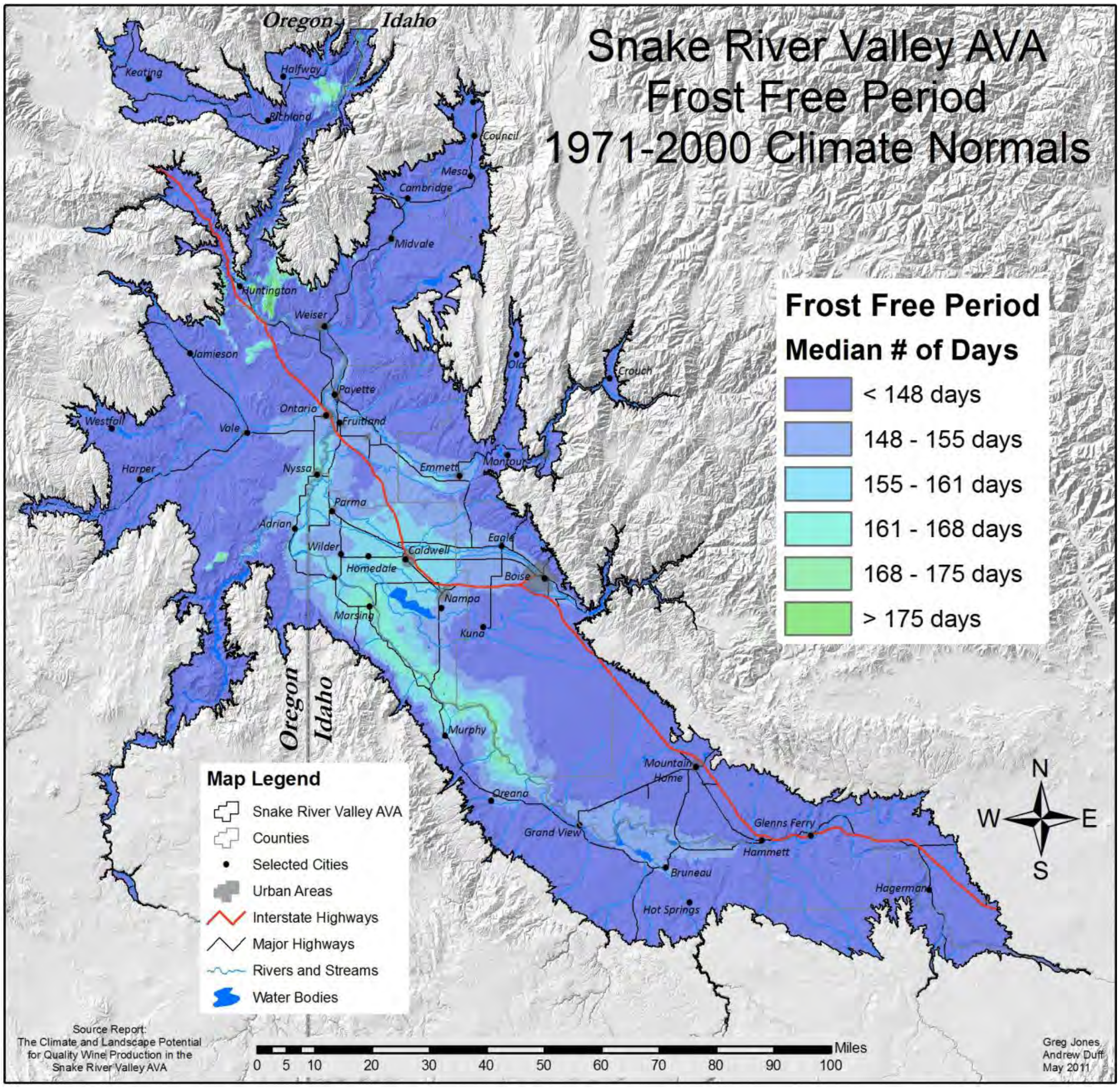

Figure 13 – The Snake River Valley AVA median length of the frost free period (between the median last spring and first fall dates with 32°F; 1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

Table 6 – Climate summary for selected stations within the Snake River Valley AVA for the 1981-2010 Climate Normals. Data is sorted by growing degree-days. Growing season average temperature and growing degree-days calculated as described in the text. For the complete 1981-2010 monthly Climate Normals see Appendix Table 2. (Data Source: NOAA, 2011, NA = not available)

Climate Station	Annual Average Temperature (°F)	Growing Season Average Temperature (°F)	Growing Degree-Days	Annual Precipitation (inches)
IRONSIDE 2 W, OR	46.1	57.6	1850	NA
GARDEN VALLEY, ID	47.1	57.9	1855	26.52
HALFWAY, OR	46.9	58.2	1908	21.87
BUHL #2, ID	49.3	60.6	2330	10.04
RICHLAND, OR	49.7	60.6	2339	15.00
COUNCIL, ID	48.7	61.1	2440	21.71
WESTFALL, OR	49.7	61.3	2474	10.49
CAMBRIDGE, ID	48.7	61.5	2511	20.98
OWYHEE DAM, OR	50.7	61.8	2535	9.68
HAGERMAN 2 SW, ID	51.0	61.9	2560	10.18
EMMETT 2 E, ID	51.0	61.9	2572	13.81
HOMEDALE 1 SE, ID	50.8	62.1	2591	NA
PARMA EXP STN, ID	51.0	62.3	2633	10.20
KUNA, ID	51.7	62.4	2660	NA
NAMPA SUGAR FACTORY, ID	51.6	62.6	2695	10.94
MALHEUR EXP STN, OR	50.9	62.6	2710	10.69
PAYETTE, ID	51.4	62.8	2749	11.16
ONTARIO KSRV, OR	50.9	62.9	2771	10.06
MOUNTAIN HOME, ID	51.4	62.8	2775	10.55
VALE, OR	51.2	62.9	2777	10.02
GRAND VIEW 4 NW, ID	52.2	63.3	2847	7.15
GLENNS FERRY, ID	52.2	63.4	2866	10.46
WEISER, ID	51.7	63.5	2899	12.62
DEER FLAT DAM, ID	52.8	63.6	2911	9.97
BOISE AIR TERMINAL, ID	52.5	63.7	2930	11.73
CALDWELL, ID	52.9	64.3	3077	11.10
HUNTINGTON, OR	52.2	64.7	3154	14.04
BRUNEAU, ID	54.7	65.5	3324	7.62
SWAN FALLS P H, ID	54.2	65.9	3413	8.20
Average	**50.9**	**62.3**	**2661**	**12.57**
Standard Deviation	**2.0**	**2.0**	**377**	**4.85**
Maximum	**54.7**	**65.9**	**3413**	**26.52**
Minimum	**46.1**	**57.6**	**1850**	**7.15**
Range	**8.6**	**8.3**	**1564**	**19.37**

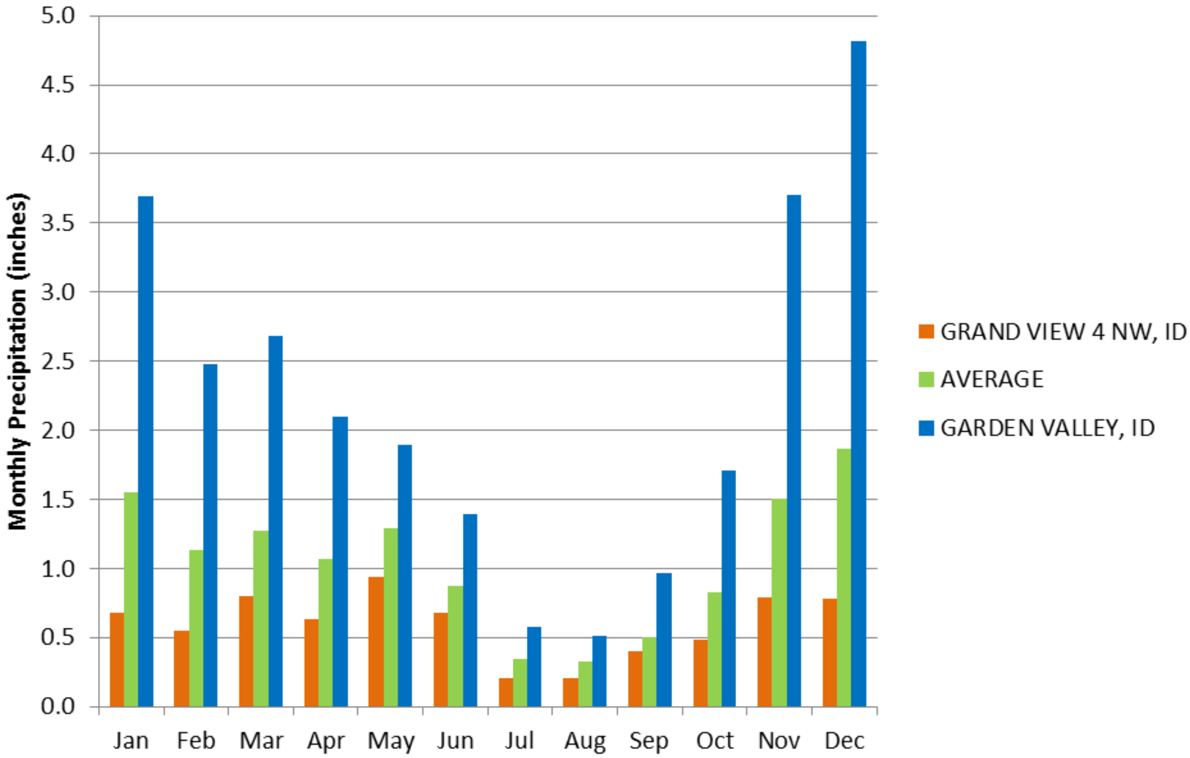

Figure 14 – Average monthly precipitation for the 29 station average in Table 6 and the driest location (Grand View, Idaho) and the wettest location (Garden Valley, Idaho). Data for the 1981-2010 Climate Normals.

Monthly GDD for these stations reveals that none typically accumulate any heat in the month of March and that eleven do not in April (Appendix Table 2, Figure 15). Furthermore, on average the majority of these stations do not accumulate a significant amount of heat during the month of October. The warmer locations (i.e., Glenns Ferry, Caldwell, and Bruneau, Idaho and Huntington, Oregon) all tend to start accumulating in April, achieve relatively higher monthly GDD during the summer (>750), and accumulate some heat during October.

Given its role in agricultural research in the region and available long term data, the Parma Experimental Station climate was examined over its entire data record (1923-2010). The data reveal that the location's average annual temperature has ranged nearly 10°F from a low of 44.9°F in 1985 to a high of 54.8°F in 1934 (Table 7). Growing season average temperatures over the locations ranged 6.1°F with a low of 58.5°F observed during 1964 and a high of 64.9°F in 2003. Average temperatures during the winter (November through March) ranged this most (11.7°F) with a low of 32.9°F experienced in 1985 and a high of 44.6°F in 1934. Growing degree-days during 1923-2010 averaged 2580 at the Parma Experimental Station and ranged nearly 1300 units from a low of 1915 GDD in 1964 to a high of 3188 GDD in 2003. Annual precipitation at the location averages 10.1 inches, but ranged 15.6 inches from a low of 3.3 inches in 1949 to a high of 18.9 inches in 1970. Compared to the 1923-2010 long term averages (Table 7), the 1981-2010 Climate Normals for these same variables (Table 6) show 0.5°F warmer annual and growing season temperatures, 1.2°F warmer winter period, an increase in 53 GDD, and no change in annual precipitation.

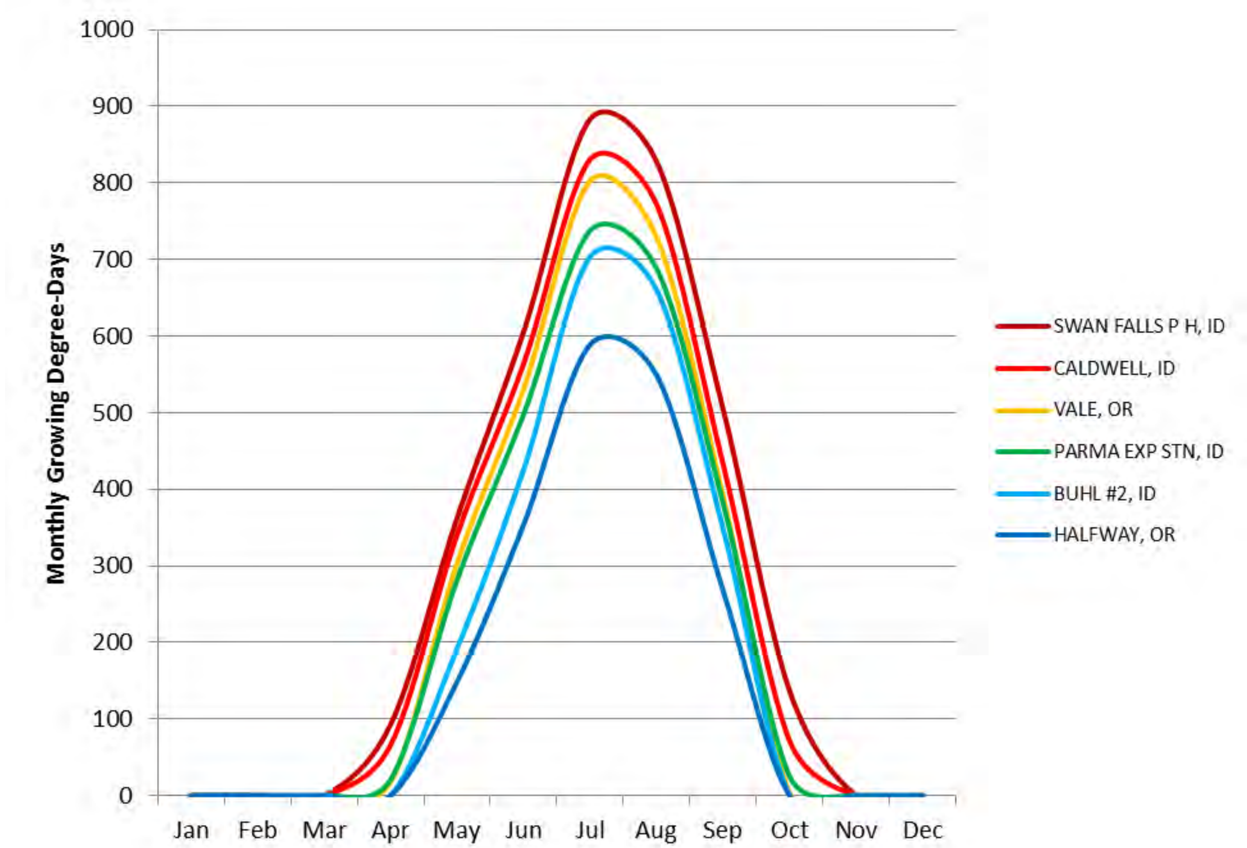

Figure 15 – Average monthly growing degree-days for selected stations from Table 6 and within the Snake River Valley AVA for the 1981-2010 Climate Normals.

Table 7 – Summary of the Parma Experimental Station climate data during 1923-2010 (Source: WRCC, 2010).

Climate Variable	Mean	Stdev	Max	Min	Range
Annual Average Temperature (°F)	50.6	1.5	54.8	44.9	9.9
Growing Season Average Temperature (Apr-Oct, °F)	61.8	1.4	64.9	58.8	6.1
Winter Average Temperature (Nov-Mar, °F)	38.9	2.3	44.6	32.9	11.7
Growing Degree-Days (Apr-Oct, base °F)	2580	280	3188	1915	1273
Annual Precipitation (inches)	10.1	2.9	18.9	3.3	15.6

An examination of daily minimum temperatures during 1923-2010 shows that the Parma Experimental Station crosses above the 32°F daily minimum on April 2nd and back below on October 22nd on average (Figure 16). However, Figure 16 shows that the location has experienced extreme minimum temperatures during the spring and fall that have dropped below 20°F. Furthermore, extreme winter temperatures, dropping below 0°F during the months of November through March, have occurred in the past. These events are typically cold air outbreaks from Alaska or Canada and commonly affect the entire region. While temperatures have dropped as low as -35°F in 1924, the last 25 years (1986-2010) have not seen winter extremes as severe, averaging 4°F with the lowest being -20.4°F in 1989 and 1990. This decline in winter severity has also been observed in other eastern Washington and Oregon wine producing regions (Jones, unpublished data). However, research has shown that declining winter severity can be problematic as both the vine and the grower get 'conditioned' to the lack of extreme minimum temperature risk and are potentially less hardy and/or less prepared for the events (Lianhong et al. 2008; Keller 2010). For maximum temperatures, the warmest period of the year is between July 7th and August 23rd, when the daily average maximum temperatures at the Parma Experimental Station are consistently over 90°F (Figure 16). Extreme maximum temperatures per year have averaged 102.8°F during 1923-2010, with a low of 97.6°F in 1993 and the highest recorded at 109.9°F in 2001. During the last 25 years (1986-2010) the location has averaged 24 days per summer over 95°F , with a low of 2 days during 1993 and a high of 55 days in 2001. It is important to note that given that both cold and warm extremes are commonly experienced all across a given region, one would expect the temporal variations described above for Parma to be more or less those experienced across the Snake River Valley AVA.

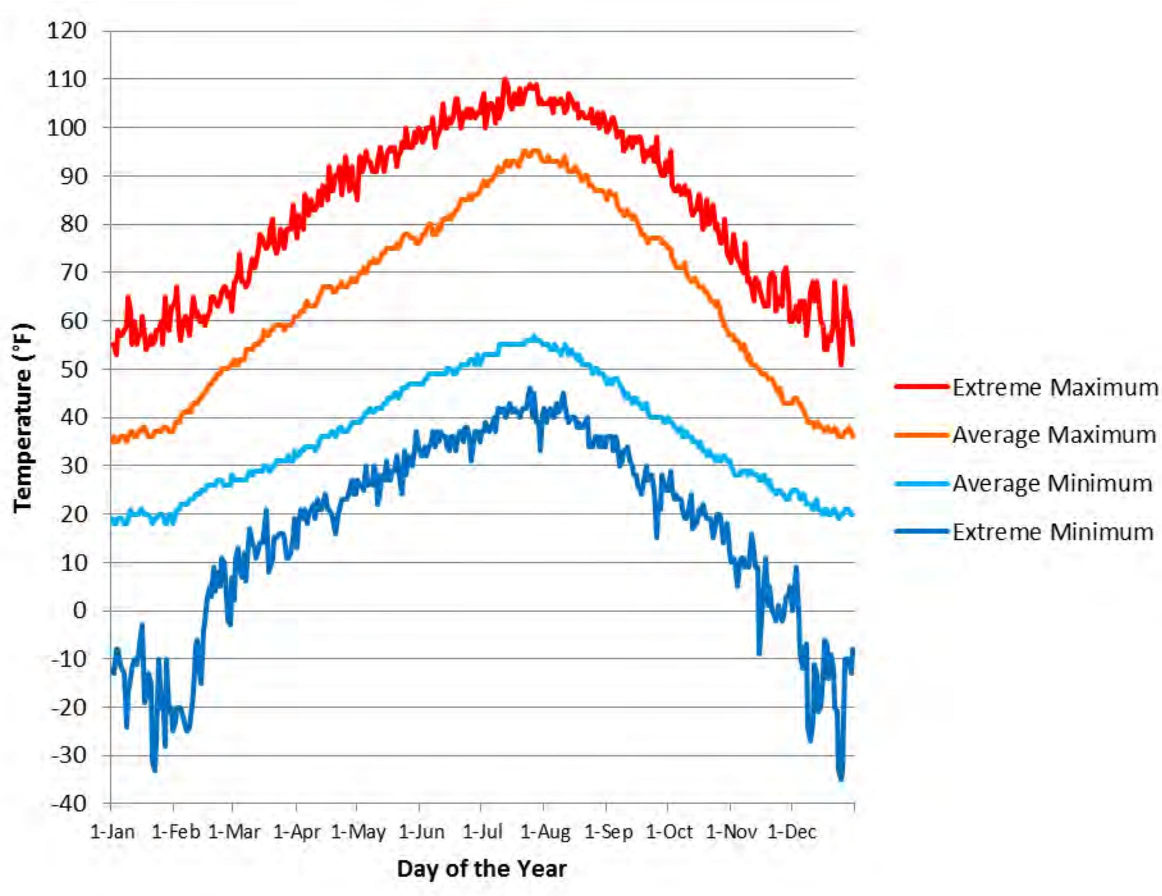

Figure 16 –Parma Experimental Station average and extreme maximum and minimum temperatures during 1923-2010 (Source: WRCC, 2010).

Given that the Snake River Valley AVA is a semi-arid to arid region, understanding water needs for irrigation is important for site suitability. Plant water requirements are typically described by the evapotranspiration rate (ET). ET is the combined amount of evaporation and plant transpiration from the Earth's land surface to the atmosphere. Factors that affect ET include a given plant's growth stage, the type of soil, the percentage of soil ground cover, solar radiation, humidity, temperature, and wind. For 1986-2010 the Parma Experimental Station experienced average daily ET rates that mirror the temperature regime for the location (Figures 16 and 17). On average ET rates climb above 0.20 inches per day by April 30th and drop below it on September 8th (Figure 17). Total growing season (April-October) ET values average 47.4 inches for the location, with a low of 40.7 inches in 1995 and a high of 52.7 inches in 1992. From these observations, the theoretical total amount of ET 'need' by the climate is 47.4 inches during the growing season. However, the ET described above and shown in Figure 17 is the 'reference ET' for the location, meaning that the value needs to be adjusted to the crop. The adjustment to crop ET is done by a coefficient, which typically changes over the growing season to account for the growth stage and size of the crop's canopy. For winegrapes at this location the crop coefficient starts out at approximately 20% of reference ET, increasing to 50% of reference ET by mid-canopy growth, and then plateauing at 65% of reference ET until the end of the season. Accounting for this coefficient, the 'winegrape' adjusted ET for the growing season averages 24.2 inches for the Parma Experimental Station (AgriMet, 2010). However, each site's ET will vary depending on the mesoclimate of the site, the irrigation system efficiency, and the overall goal for the vineyard.

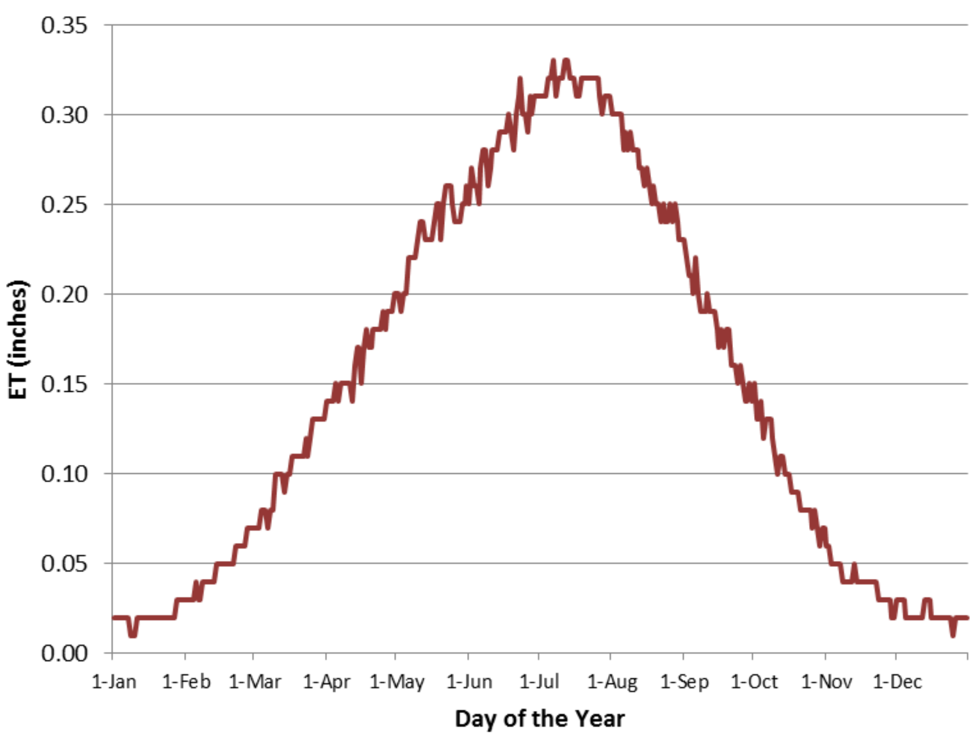

Figure 17 –Parma Experimental Station AgriMet average daily evapotranspiration values during 1986-2010 (Source: AgriMet, 2010).

Terroir Zoning Data and Methods:

To analyze the terroir of the Snake River Valley AVA, a multi-stage Geographic Information System (GIS) analysis was set up to incorporate factors related to the topography, soils, land zoning, and climate (Figure 18). Terroir zoning studies typically encompass the general characteristics of each factor separately then combine them into a composite depiction of a region's suitability (Wolf, 1997; Vaudour, 2002; Jones et al. 2004; Jones et al. 2006). The sections below explain in further detail each of the separate suitability factors and the data and methods used to assess them.

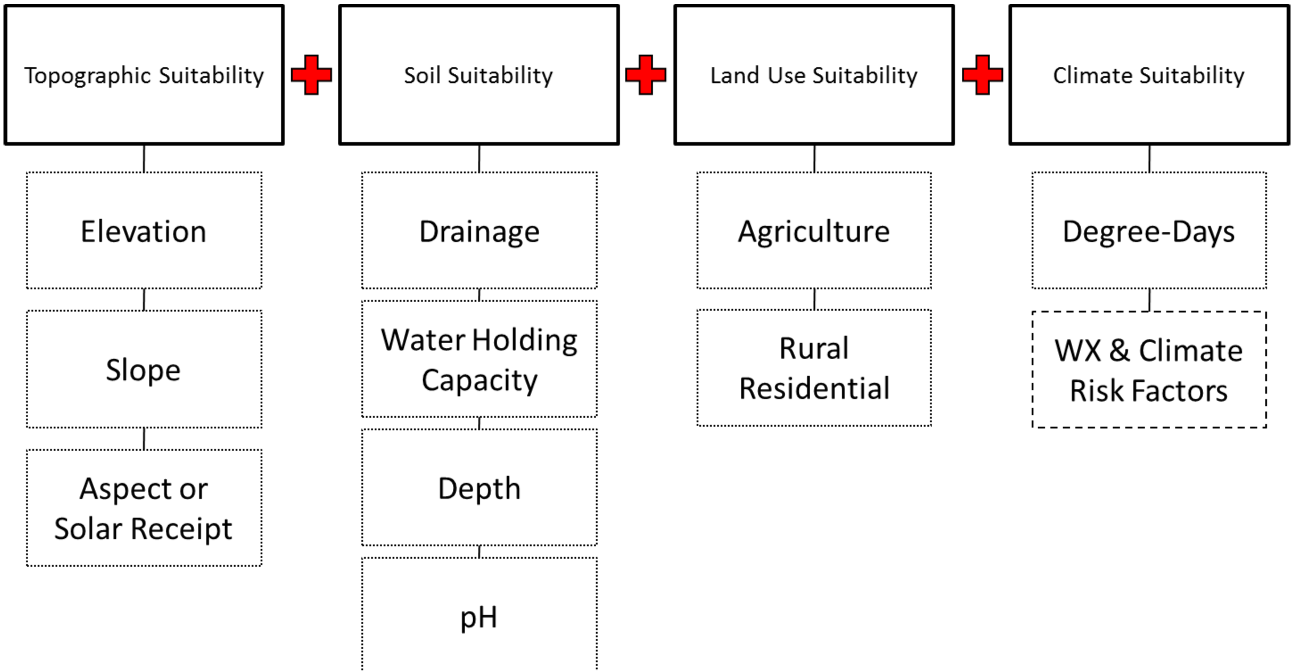

Figure 18 – Generalized terroir zoning model of the approach used in this study.

Topographical Suitability

The topographical landscape was analyzed through the use of United States Geological Survey 10 meter digital elevation models (DEM). The entire landscape in the Snake River Valley AVA was then categorized for the most advantageous elevations, slopes, and solar illumination characteristics for growing grapes. The categorization was constructed as a multi-layer, topographically-driven suitability analysis using ArcGIS (ESRI, 2011) with class rankings given each grid (data layer) based on its potential. The suitability of elevations was determined from conversations with growers (Ron Bitner, personal communication), research personnel (Krista Shellie and David Wilkins, personal communication), and knowledge of the variations in climate structure over the landscape in the region. Elevations between 2250 and 2800 ft were given the two highest values due to lying within the optimum thermal zone of the region. Suitability decreases both at lower and higher elevations due to cold air pooling at lower elevations and decreases in temperature with height above the thermal zone (Table 8). All elevations above 3400 ft were considered not suitable due to low heat accumulation, winter freeze risk, and spring and fall frost risk (see section on Climate Suitability).

Slopes were categorized into seven classes from less than 1% (or basically flat with poor cold air drainage) to those over 30% being classed not suitable (increasing slopes cause problems using vineyard equipment). However, note that slopes over 30% can be planted, but at a higher cost of development and management. The best slopes are considered to be those in the 5-20% range (Table 9). While the aspect of the landscape is typically used to define solar exposure, aspect alone does not account for obstructions such as other hills or swales in the landscape (shadows) and does not factor in the sum total of the vertical variations in solar receipt and the seasonal variation in solar declination and azimuth. Capturing a more realistic solar receipt (compared to standard aspect) allows for a better depiction of the spatial variability of microclimates, including factors such as air and soil temperature regimes, evapotranspiration, snow melt patterns, soil moisture, and light available for photosynthesis. To create a solar illumination grid this analysis uses GIS tools to account for atmospheric effects, site latitude and elevation, steepness (slope) and compass direction (aspect), daily and seasonal shifts of the sun angle, and effects of shadows cast by surrounding topography. To minimize computation time, but capture the nature of the solar illumination in the region, the analysis was run from April 15 ending September 15 (approximating the peak solar period), at a 14 day interval and a 2 hour interval (11 weeks x 12 hour steps per week = 132 solar illumination grids). All of the weekly/hourly grids were added together to produce a cumulative solar illumination grid that was categorized into five classes with those with the greatest solar illumination, and therefore ripening potential, given the highest ranking (Table 9). The three separate grids (elevation, slope, and solar illumination) were then added together to produce a single topographical suitability grid with values ranging from not suitable (coming from either being too high in elevation or on extremely steep slopes) and least suitable through most suitable landscapes.

Table 8 – Elevation categorization of the landscape in the Snake River Valley AVA (see Figure 1) using a 10 meter digital elevation model. Class rankings represent a range of values related to the relative suitability (all elevations above 3400 ft were considered not viable).

Elevation (feet)	Suitability Ranking
1600-2100	2
2100-2250	3
2250-2400	4
2400-2600	5
2600-2800	4
2800-3000	3
3000-3200	2
3200-3400	1
> 3400	Not suitable

Table 9 – Slope and solar illumination categorization of the landscape in the Snake River Valley AVA (see Figure 1) using a 10 meter digital elevation model. Note that solar illumination is directly comparable to aspect, but takes into account shading by other landscape features. Solar illumination is given in average Watts per m^2 and is derived from the number of hours of direct solar radiation received by each grid during April 15 through September 15 at a two week and two hour time step (see text for more details).

Slope (%)	Class Ranking	Solar Illumination (W/m^2)	Class	Class Ranking
< 1 (flat)	1	< 400	Poor Receipt	1
1 - 5	2	400 - 500	Marginal Receipt	2
5 - 10	4	500 - 600	Fair Receipt	3
10 - 15	5	600 - 700	Good Receipt	4
15 - 20	4	700 - 850	Excellent Receipt	5
20 - 30	3			
>30	Not Suitable			

Soil Suitability

To analyze the Snake River Valley AVA's soils, spatial data were obtained from the Soil Survey Geographic (SSURGO) Database for multiple regions in the AVA (NRCS, 2010). Overall there were 15 total SSURGO soil regions available for this assessment (eleven in Idaho and 4 in Oregon). Unfortunately there were some limitations on SSURGO soils just to the north and east of Boise, but mostly on the Oregon side of the AVA (Figure 19). Site suitability relative to soils is analyzed in a similar manner to Margary et al. (1998) for New York, Oregon (Jones et al., 2004; Jones et al., 2006), and Washington (Jones and Duff, 2007) with minor adjustments made for soils found in Idaho (Stulz, 2001). Four soil properties were used in the categorization of suitability: drainage, depth to bedrock, available water holding capacity, and pH. It should be noted that the lack of soils data in some areas (mostly Oregon) resulted in these areas not being fully incorporated into the soils and ultimately the overall suitability model. However, it is likely that some of the soils in these areas are suitable for viticulture and will need to be furthered assessed at the site level.

Drainage is thought to be the most important soil factor in establishing and maintaining a vineyard (Cass, 1999) and is influenced by many structural issues such as texture, depth, slope, and aspect. To assess soil drainage, the SSURGO database was analyzed by individual Hydrologic Soil Groups by map unit in the database. The four groups represent variations in drainage from good to poor (groups A to D). Depth to bedrock gives an indication of how well vines can cope with dry periods, with a minimum of 10-40 inches generally needed (Jordan et al., 1980; Dry and Smart, 1988). Mean depth to bedrock was calculated using the SSURGO database from the low to high bedrock depths for each component, and a weighted average was obtained for each map unit. While drainage is extremely important in vineyards, a soil's available water holding capacity (AWC) is important as those soils with adequate water holding capacity are at an advantage, giving vines the greatest ability to tolerate periods of moderate drought (Cass, 1999). AWC was calculated from the SSURGO database by computing the mean value for each soil layer, summed over the layers for each component, and then weighted by the percentage of each component per map unit (Margary et al., 1998). Soil pH gives an indication of fertility and nutrient balance with most ideal vineyard soils being found between 5.5 and 8.0. Outside this range, nutrients may become out of balance, with deficiencies or toxic levels effecting vine uptake or beneficial relationships with microorganisms. Soil pH was computed from the SSURGO database by computing the mean value for each soil component and then weighting by the percentage of each component per map unit.

Table 10 – Criteria for developing the soil suitability in the Snake River Valley AVA using the SSURGO soils database and the area available in Figure 19. The soil factors were classed based on general characteristics suitable for viticulture and then weighted to produce a final soil suitability grid.

Soil Factor	Lower Threshold	Upper Threshold	Number of Classes	% Weighting
Drainage	Poor	Excessive	4	40
AWHC (inches H_2O/inches soil)	0.0	0.45	5	20
Depth to Bedrock (inches)	0	250	4	20
pH	4.5	10.0	4	20

The spatial data for each soil characteristic was then converted to grids at the same 10 meter resolution to match the landscape suitability grid. Each soil factor was then grouped into classes based upon their individual values found over the available soils data area in Figure 19; drainage from poor to excessive, available water holding capacity from 0.0-0.45 inches of water per inch of soil; depth to bedrock from 0-250 inches; and pH from values from 4.5-10.0 (Table 10). All classes in each grid were then scaled and weighted with drainage given the greatest weight (40%) and each of the other factors weighted 20%. A final grid of soil suitability was then constructed from the weighting of the four soil factors.

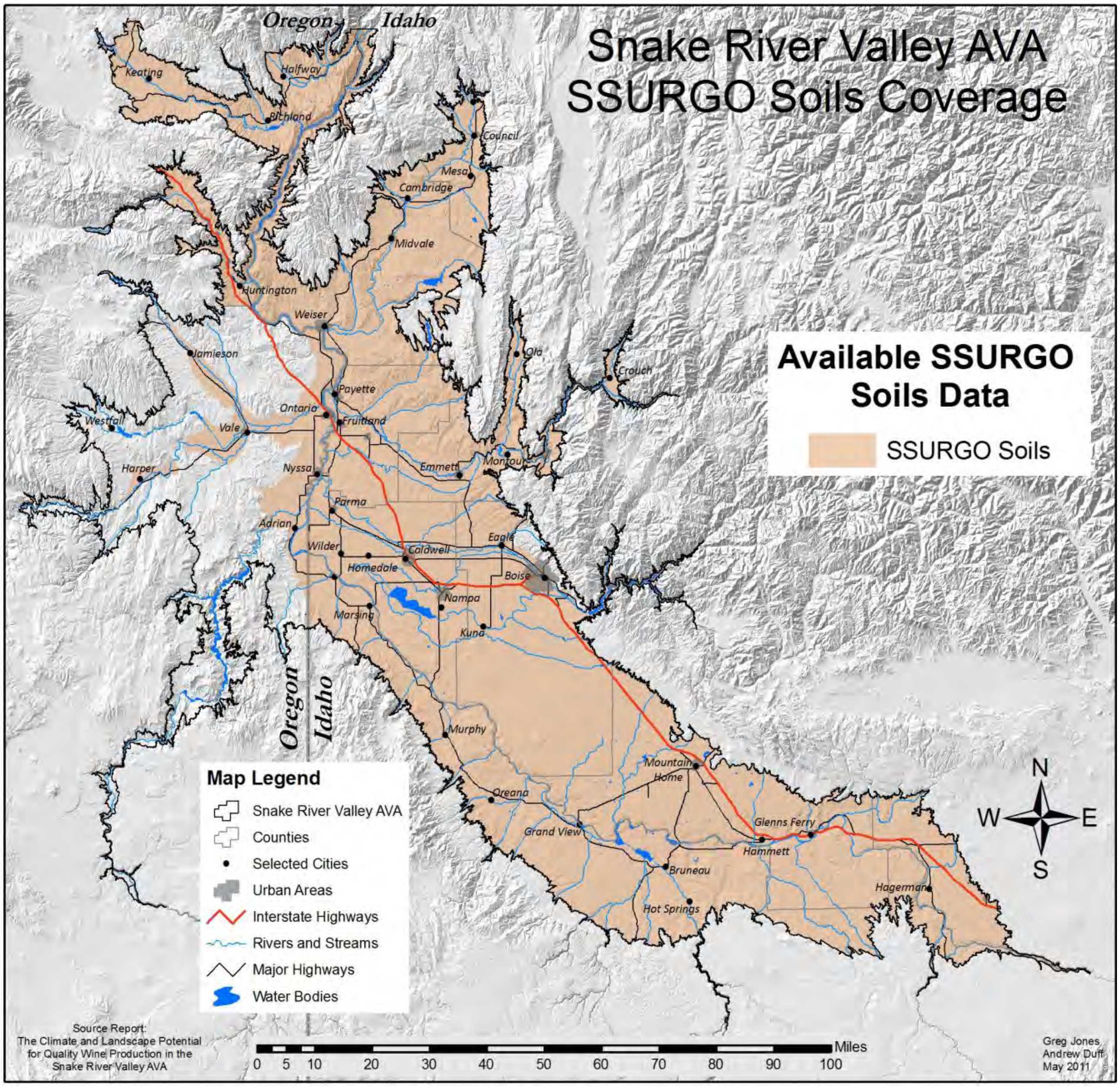

Figure 19 – Available SSURGO Soils data in the Snake River Valley AVA. Areas to the west in Oregon and to the north and east of Boise were not available at the time of this analysis.

Land Use Suitability

Land availability and zoning are important for any developmental process today. However, a comprehensive regional land use data set for Idaho or the Snake River Valley AVA was not available. To incorporate land use issues relative to the potential for agricultural development, this analysis uses the Protected Areas Database for the United States from the Conservation Biology Institute (CBI, 2010). Protected areas are the foundations around which regional, national and international conservation strategies are developed. The Protected Areas Database therefore allows users to assess what lands are protected anywhere the United States and easily use this inventory for conservation, land management, planning, recreation and other uses. An example of the use of this data is from a USGS version of the Protected Area Database that is used in GAP Analyses for understanding the distributions of vertebrate species. While the data is more geared toward conservation through understanding the local of Federal, Local, and State lands and Private Conservation lands, the CBI identifies and aggregates unprotected lands into a “private lands matrix” feature which includes land that is typically available for development, potentially including agriculture. To account for these ‘privately’ held lands this analysis groups all private and unknown (considered most likely to be held in private hands) lands into a grid that is ultimately used to mask the landscape and soils suitability grids (see below).

Climate Suitability

To depict the spatial climate characteristics in Snake River Valley AVA, this research utilizes the PRISM gridded climate dataset described previously. When assessing a region’s potential the most recognized method of climate suitability for viticulture is the use of heat accumulation (Jones, 2005) and in the western US the most common method is the use of growing degree-days (GDD). Therefore, this assessment calculated GDD from the 1971-2000 PRISM Climate Normals to help establish the Snake River Valley AVA climate suitability. Climate-maturity groupings for standard Winkler Regions classes (Table 1) and updates to the lower Region I and upper limit of Region V classes found by Jones et al. (2010) and Hall and Jones (2010) are used in this assessment (Table 11). However, it is important to note that the climates today are better represented by the 1981-2010 Climate Normals, but they have not been updated in the PRISM data model by the time of this report. Given the general trends in the data from individual stations (NOAA, 2011), one could reasonably expect the magnitude of the GDD values to increase by 5-15% from the 1971-2000 to the 1981-2010 Climate Normals.

Table 11 – Growing degree-day criteria for suitability ranking based on Winkler Regions (see Winkler et al. 1974) and practical knowledge from the general limits in the western United States (see Jones et al. [2010] and Hall and Jones [2010]). Growing degree-days are calculated from the 1971-2000 PRISM Climate Normals using a base of 50°F with no upper cut-off and accumulated over the April through October period.

Growing Degree-Day Classes	Description	Winkler Region
< 1500	Not Viable	
1500-2000	Very Cool Suitability	Region Ia
2000-2500	Cool Suitability	Region Ib
2500-3000	Intermediate Suitability	Region II
3000-3500	Warm Suitability	Region III
3500-4000	Very Warm Suitability	Region IV
4000-4900	Hot Suitability	Region V

Given that frost timing and frequency is a critical factor in a given site or region's ability to be economically viable (Gladstones, 1992; Wolf, 1997; Jones and Hellman, 2003), this analysis uses frost dates and the frost-free period as a 'climate risk' factor. The PRISM data covers the median date of the last spring frost and the median date of the first fall frost based upon the 1971-2000 Climate Normals. The dates were classified into weekly class ranges (Table 12) based on research trials on phenology in the region (Shellie, 2007), other vineyard observations, and general knowledge of risk limits for the varieties grown in the region. Relative risk increases as the median date of the last spring frost moves into May and becomes not suitable when its occurrence is later than May 28th. For the first fall frost, relative risk is low when the first fall frost occurs from the middle of October or later and is not suitable when the median date occurs prior to September 23rd (Table 12). The number of days between the last spring and first fall frosts is the median frost-free period, which is often considered the length of the growing season (Jones and Hellman, 2003). The PRISM median spring and fall frost date grids are subtracted to produce a median frost-free period grid and classed into seven day groups based upon low risk (longer than 175 days) to not suitable (less than 148 days). These three grids are then combined into a 'climate risk' factor, which is used to delineate zones of low to high risk. The result is then used to overlay the overall GDD-Landscape suitability.

Table 12 – Median values for the last spring frost, first fall frost, and the frost-free period from the 1971-2000 PRISM Climate Normals for the Snake River Valley AVA.

Last Spring Frost (32°F)		**First Fall Frost (32°F)**		**Frost-Free Period**	
Median Date	**Relative Risk**	**Median Date**	**Relative Risk**	**Median # of Days**	**Relative Risk**
< Apr 24	Low	< Oct 28	Low	> 175	Low
Apr 24 - May 1		Oct 21 - 28		168-175	
May 1 - 7		Oct 14 - 21		161-168	
May 7 - 14		Oct 7 - 14		155-161	
May 14 - 21		Sept 30 - Oct 7		148-155	High
May 21 - 28	High	Sept 23 - 30	High	< 148	Not Suitable
> May 28	Not Suitable	< Sept 23	Not Suitable		

Composite Suitability

The three main terroir zoning factors – topography, soil, and land use grids – after being internally scaled relative to their individual grape growing influences (as defined above), were then combined to produce a composite suitability map taking into account the combined effects of landscape/soils and limited by privately held lands. The composite map was then masked with the climate maturity group map (GDD) to produce a spatial depiction of the best zones in each climate group in the Snake River Valley AVA.

Results:

Topographical Characteristics and Suitability:

Using region wide digital elevation model (10 m DEM) data along with the criteria for topographic suitability for the Snake River Valley AVA (Table 8) produces spatial depictions of elevation, slope, and solar radiation receipt (illumination) over the region. In terms of elevation suitability (Figure 20), the most suitable landscapes in the Snake River Valley AVA are along the main stem of the Snake River from the SE portion of the AVA to near Murphy where it widens across the Treasure Valley. Suitable elevations extend across the border into Oregon and up along most of the rivers that drain into the Snake River (the Malheur, Owyhee, Powder, and Burnt rivers in Oregon and the Payette, Boise, and Weiser rivers in Idaho). There are some areas within the AVA that are considered too high for viticulture and can be found in Oregon in the upper elevations above the Owyhee River, south of Midvale near Star Butte, to the east of Huntington, and numerous isolated buttes or uplands in the far southeast, west, and northern sections of the AVA (Figure 20). In terms of slope suitability for good air drainage, ease of farming, and solar radiation receipt the region has a widely varying landscape with much of the lower river plains being too flat and the majority of the best slopes scattered throughout the mid to upper elevation zones (Figure 21). The challenge here is that optimum slope suitability between 5 to 20% slopes is often above the main rivers and potentially outside of irrigation water access. Combined, the elevation and slope characteristics of the landscape produce strong gradients in solar radiation receipt, or the illumination of the landscape (aspect with obstructions taken into account). For the Snake River Valley AVA the vast majority of the region has intermediate solar receipt (fair to good receipt) with the lowest amounts found along the canyons of the main rivers and on north or northeast facing slopes (Figure 22). Higher solar receipt is found in the open landscapes from Boise southeast toward Mountain Home and Twin Falls.

Combining elevation, slope, and solar illumination produces a composite topographic suitability and finds over 135,000 hectares that meet the best overall suitability for planting winegrapes in the region (Table 13). These sites represent mid-level elevations, with moderate slopes, and intermediate to high solar receipt and are found along the Snake River from the southeastern corner of the AVA and then broadly over the greater Treasure Valley uplands (Figure 23). Lower than average composite topographic suitability is found along the main stem of the Snake River from near Homedale to northwest of Weiser results from flatter landscapes and zones with potential cold air pooling issues (freeze and/or frost zones).

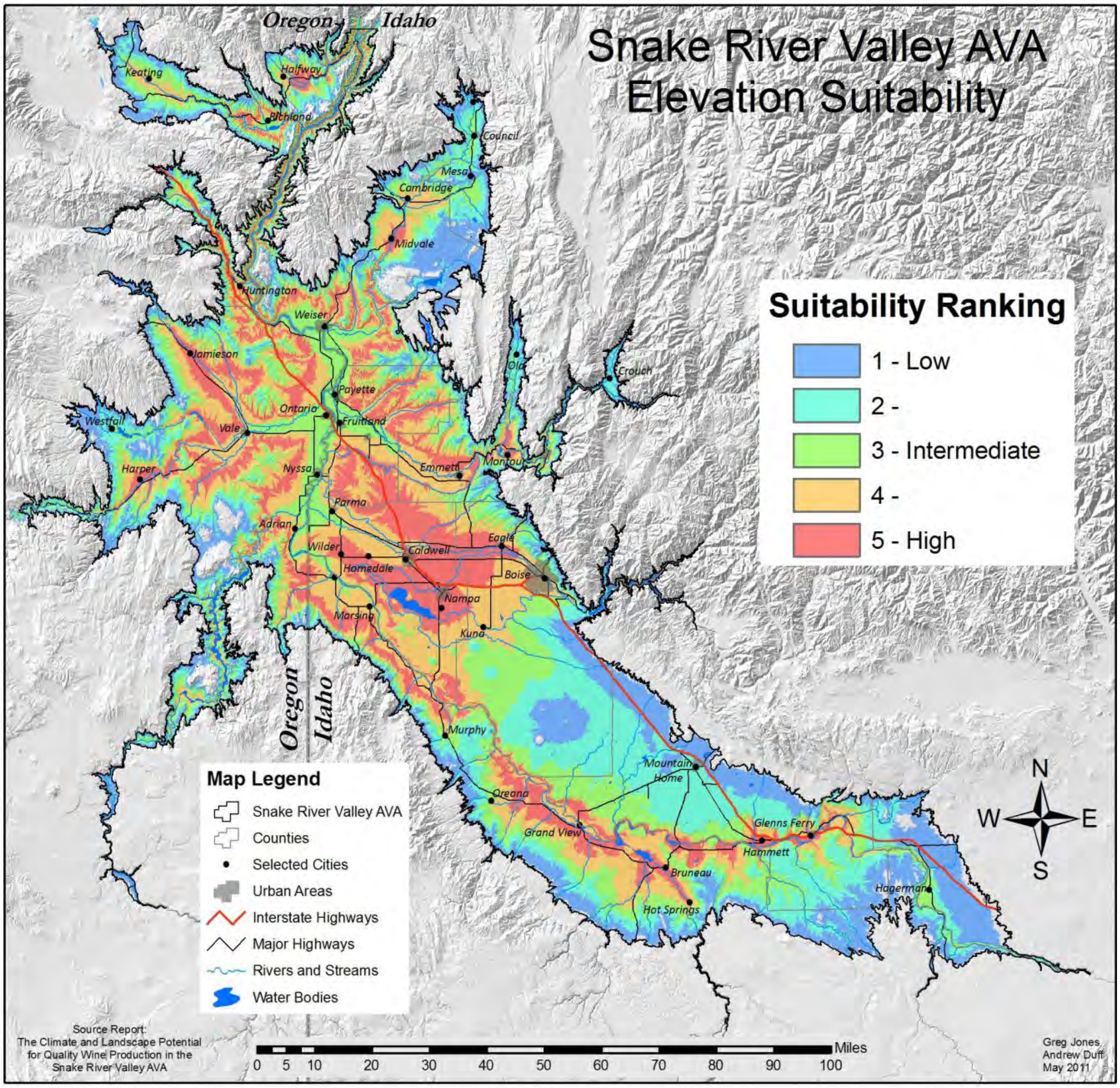

Figure 20 – The Snake River Valley AVA elevation suitability for viticulture based on the criteria given in Table 8 and described in the text. (Data Source: USGS, 2010).

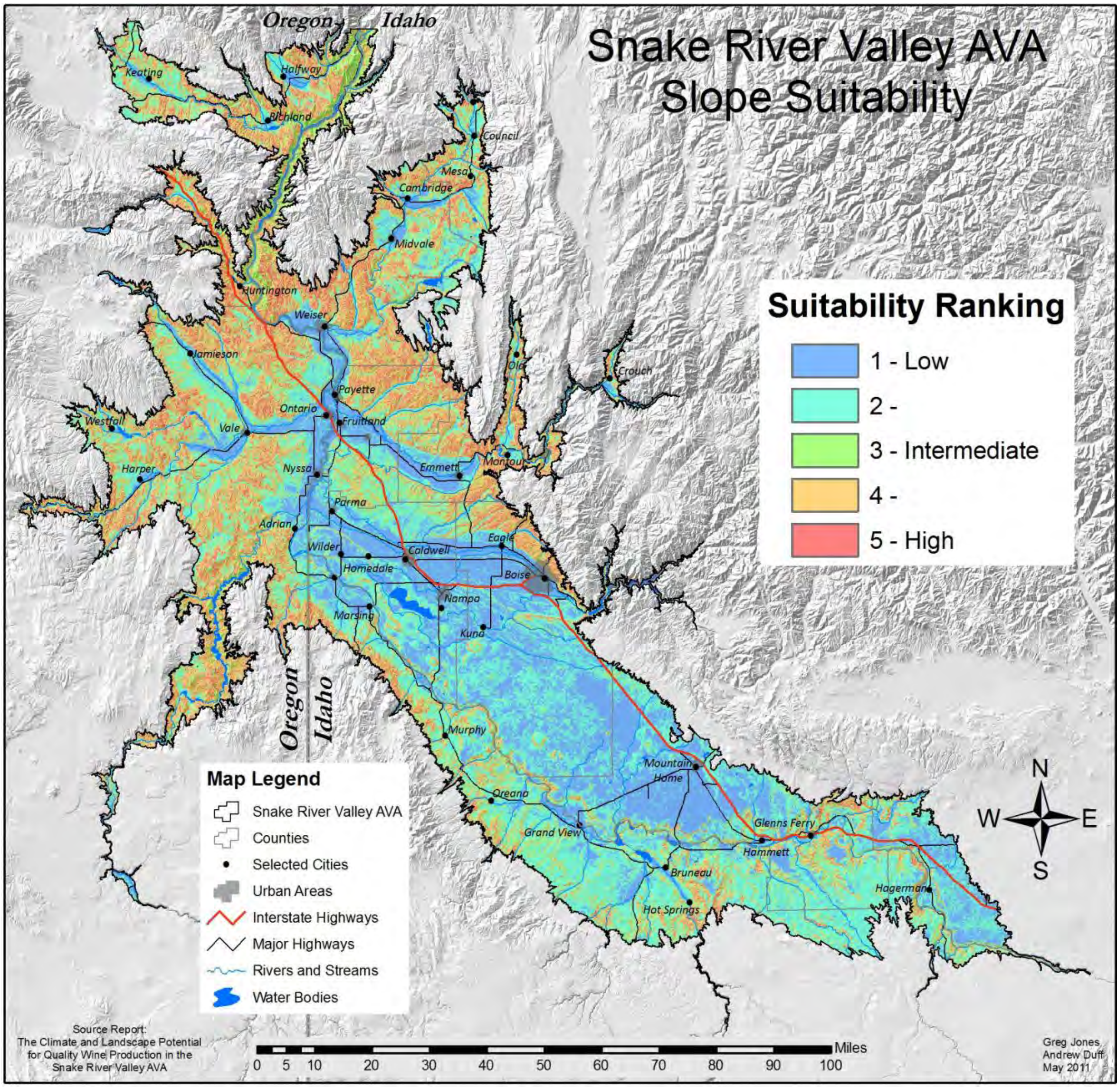

Figure 21 – The Snake River Valley AVA slope suitability for viticulture based on the criteria given in Table 9 and described in the text. (Data Source: USGS, 2010).

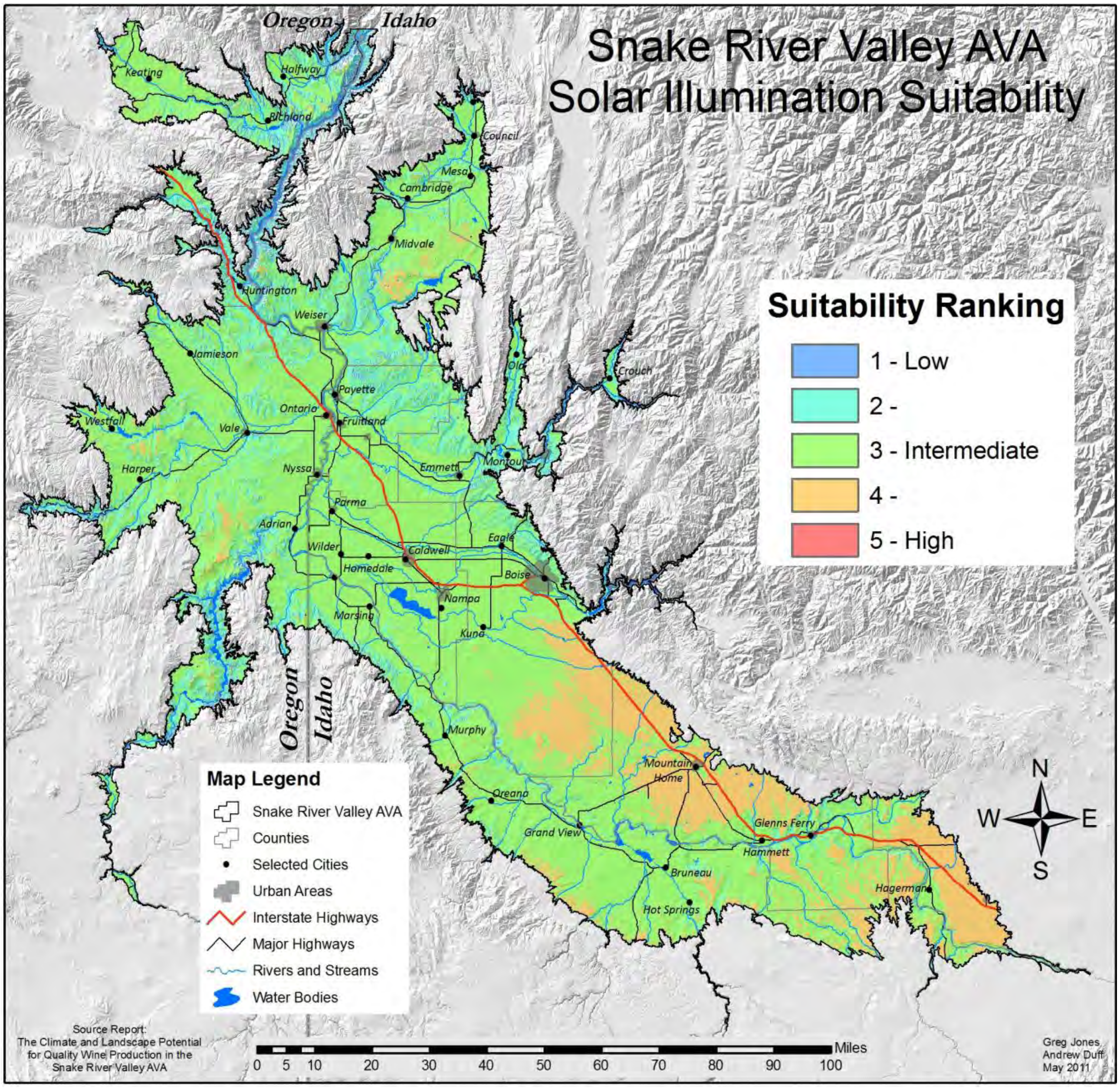

Figure 22 – The Snake River Valley AVA solar radiation receipt suitability (illumination) suitability for viticulture based on the criteria given in Table 9 and described in the text. (Data Source: USGS, 2010).

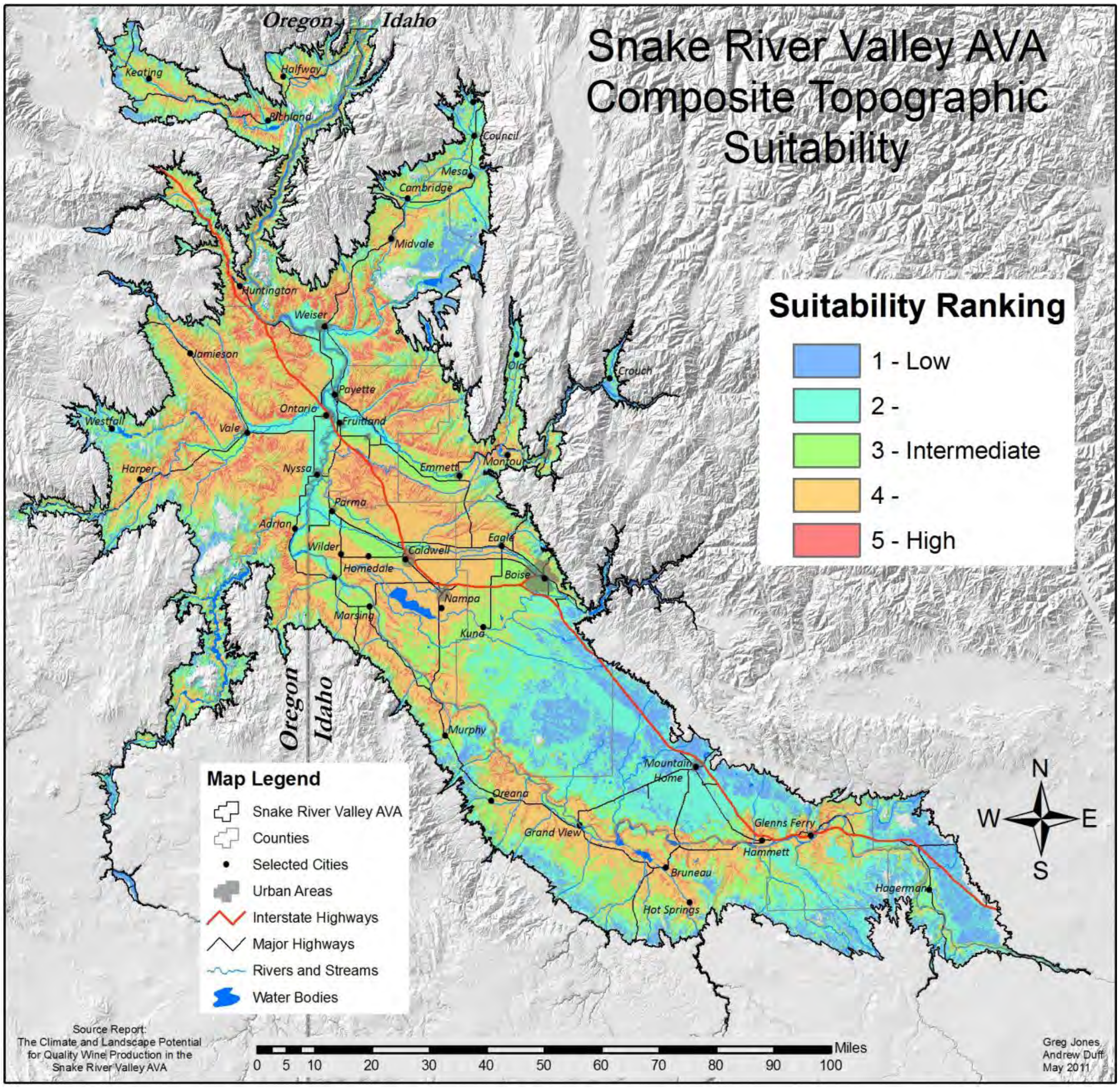

Figure 23 – The Snake River Valley AVA combined topographic suitability for viticulture derived from the combination of elevation, slope, and illumination (Tables 8-9 and Figures 20-22). (Data Source: USGS, 2010).

Table 13 – Combined topographic suitability (elevation, slope, and solar illumination) in the Snake River Valley AVA based on the spatial distribution shown on the map in Figure 23.

Suitability	Hectares
Low Suitability	279,428
-	457,117
Intermediate Suitability	469,518
-	731,024
High Suitability	135,261
Total	*2,072,348*

Soil Characteristics and Suitability:

While soil characteristics can vary tremendously over the landscape, the use of spatial data on soils from the National Resource Conservation Service (NRCS, 2010) gives a reasonable picture of what can generally be expected over a given region. For the Snake River Valley AVA drainage characteristics range from 1) Group A soils which are typically deep sandy loams with excessively drained sands and gravels; 2) Group B which are commonly moderately deep to deep loam and to silt loam with moderately coarse textures and drainage; 3) Group C which is mostly sandy to silty clay loams with fine texture and some impediments to drainage; and 4) Group D which are typically silty clay loams or strongly clayey soils with high runoff potential due to poor infiltration rates and drainage. Group D soils also typically have swelling potential during wet periods and a high water table, a clay layer at or near the surface, and/or shallow soils over nearly impervious material. Over the area of SSURGO soils available for the Snake River Valley AVA (Figure 19) much of the area (~55%) is either in Group B (good drainage, suitability ranking 4) or Group A (high drainage, suitability ranking 3) (Figure 24). The best drained soils are found along the Snake River from the southeastern section of the AVA and in the highlands above the Boise, Payette, Weiser, Malhuer, and Burnt rivers and Willow Creek northwest of Vale, Oregon. Soils with low drainage are typically heavier clays and/or soils with caliche (hard layers called duricrust or duripans) with depth. These are found in many of the higher elevation zones in the AVA and along the main stem of the rivers.

Depth to bedrock across the Snake River Valley AVA varies tremendously with the deepest soils being found in regions with prominent wind or river derived deposits (Figure 25). The available SSURGO data estimates soils that average 54 inches but range up to 250 inches in the region; however there are likely zones with deeper soils throughout the region. Shallow soils are found in zones with prominent river scouring, mountainous areas, or areas with basalt bedrock near the surface. In terms of pH the SSURGO soils data for the Snake River Valley AVA depict a region with relatively basic soils, averaging 7.4 and with the majority of the soils between 6.7 and 8.7. As mapped in Figure 26 the region largely has suitable soil pH for viticulture. In a relatively arid region like the Snake River Valley available water holding capacity (AWC) of the soil is important because having moderate capacity increases the ability of the vines to access soil water during times of seasonal drought and makes irrigation more effective. Overall the SSURGO data for the Snake River Valley AVA shows that the region provides low to moderate AWC averaging 0.16 inches of water per inch of soil (main range is 0.10 to 20 in/in). Limiting soils with low AWC are mostly found in the far southeast corner of the AVA, in scattered zones along the Snake River up to Marsing and in the northeast section of the AVA in Idaho (Figure 27).

The weighted composite soil suitability (drainage, available water holding capacity, depth to bedrock, and pH) finds over 400,000 hectares that meet the best overall suitability for planting winegrapes in the region (Table 14). The highest suitability is found mostly in the uplands in the Treasure Valley, in numerous sections along the Snake River, and near Mountain Home (Figure 28). Low composite soil suitability, seen along the northern reaches of the Snake River, in portions of the Weiser and Payette river valleys, and in numerous areas in the southeast portion of the AVA, largely results from poor drainage and shallow soils, and to a lesser degree on low water holding capacity.

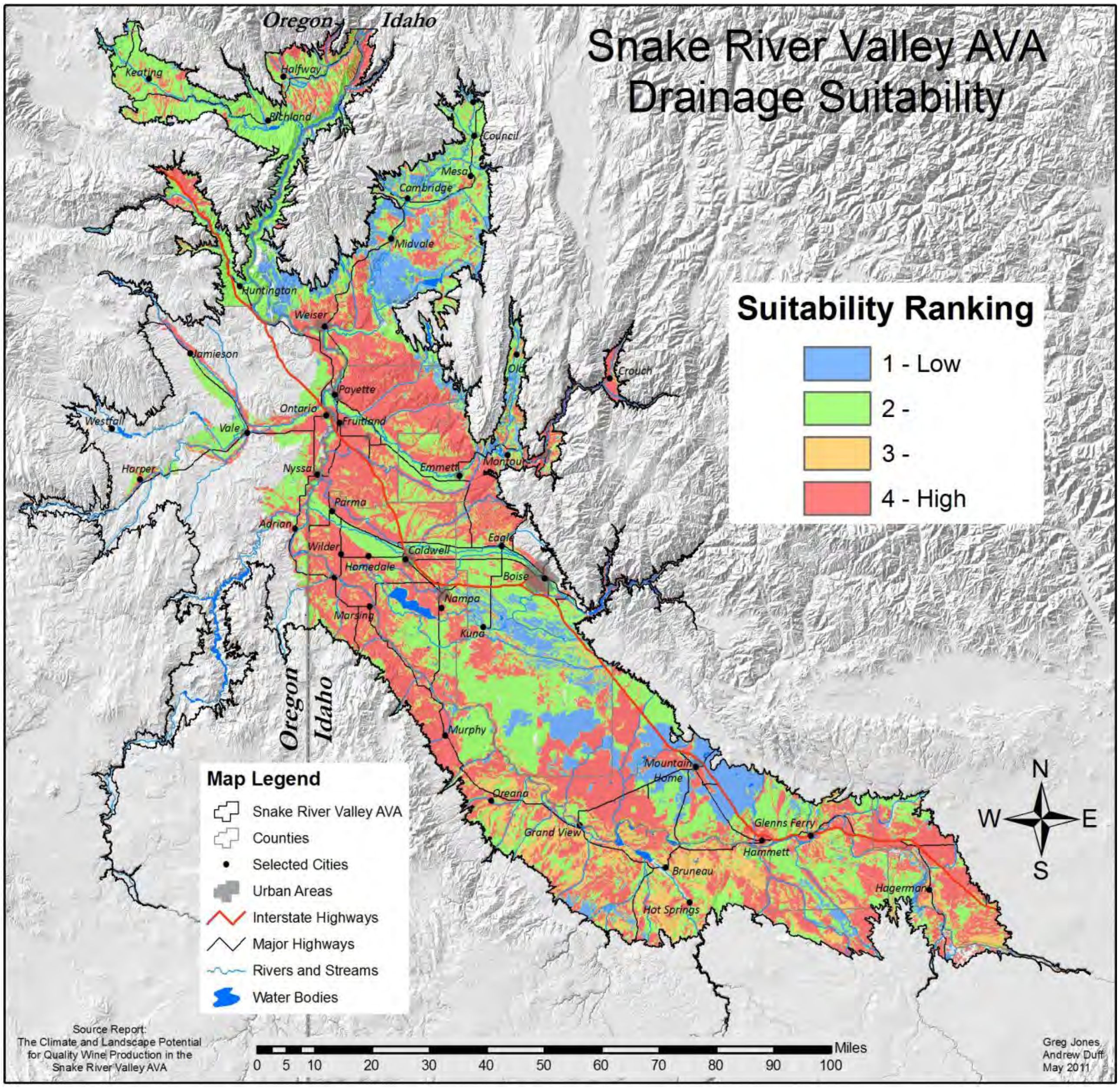

Figure 24 – The Snake River Valley AVA soil hydrologic soil group drainage classes (low to high drainage) suitability for viticulture based on the criteria given in Table 10 and described in the text. (Source: NRCS, 2010).

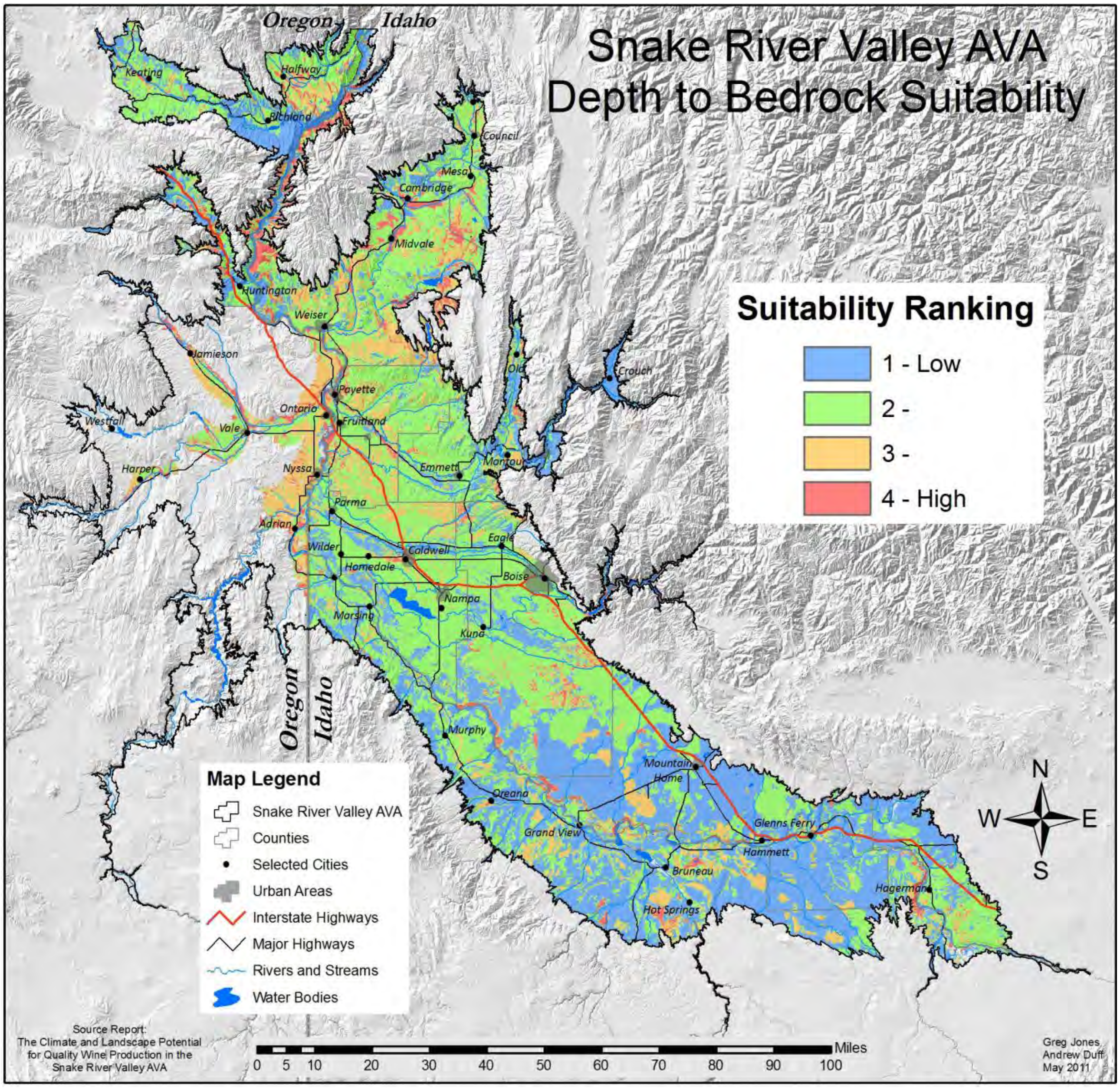

Figure 25 – The Snake River Valley AVA soil depth to bedrock classes (low to high depths) suitability for viticulture based on the criteria given in Table 10 and described in the text. (Source: NRCS, 2010).

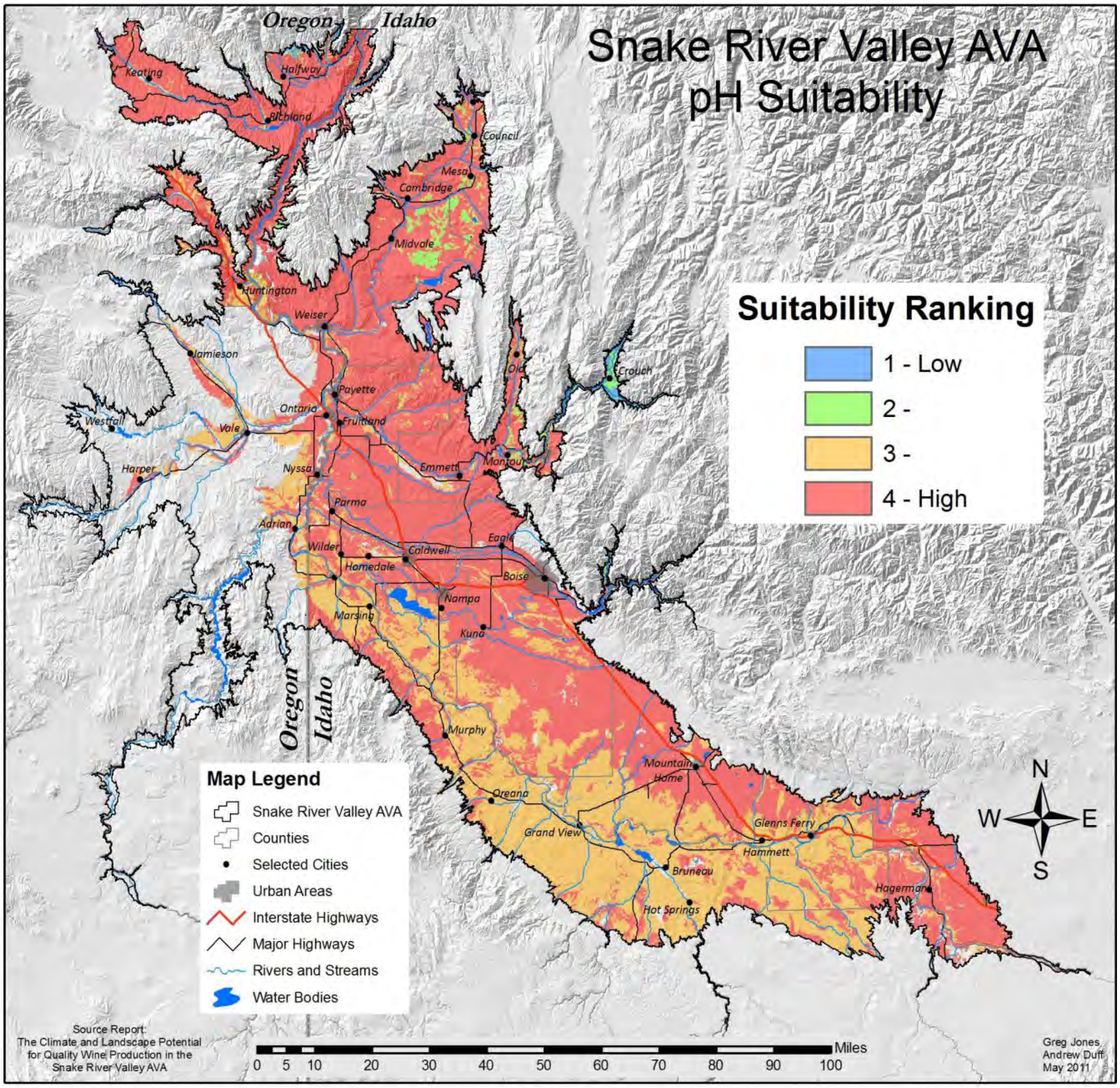

Figure 26 – The Snake River Valley AVA soil pH classes (low to high pH) suitability for viticulture based on the criteria given in Table 10 and described in the text. (Source: NRCS, 2010).

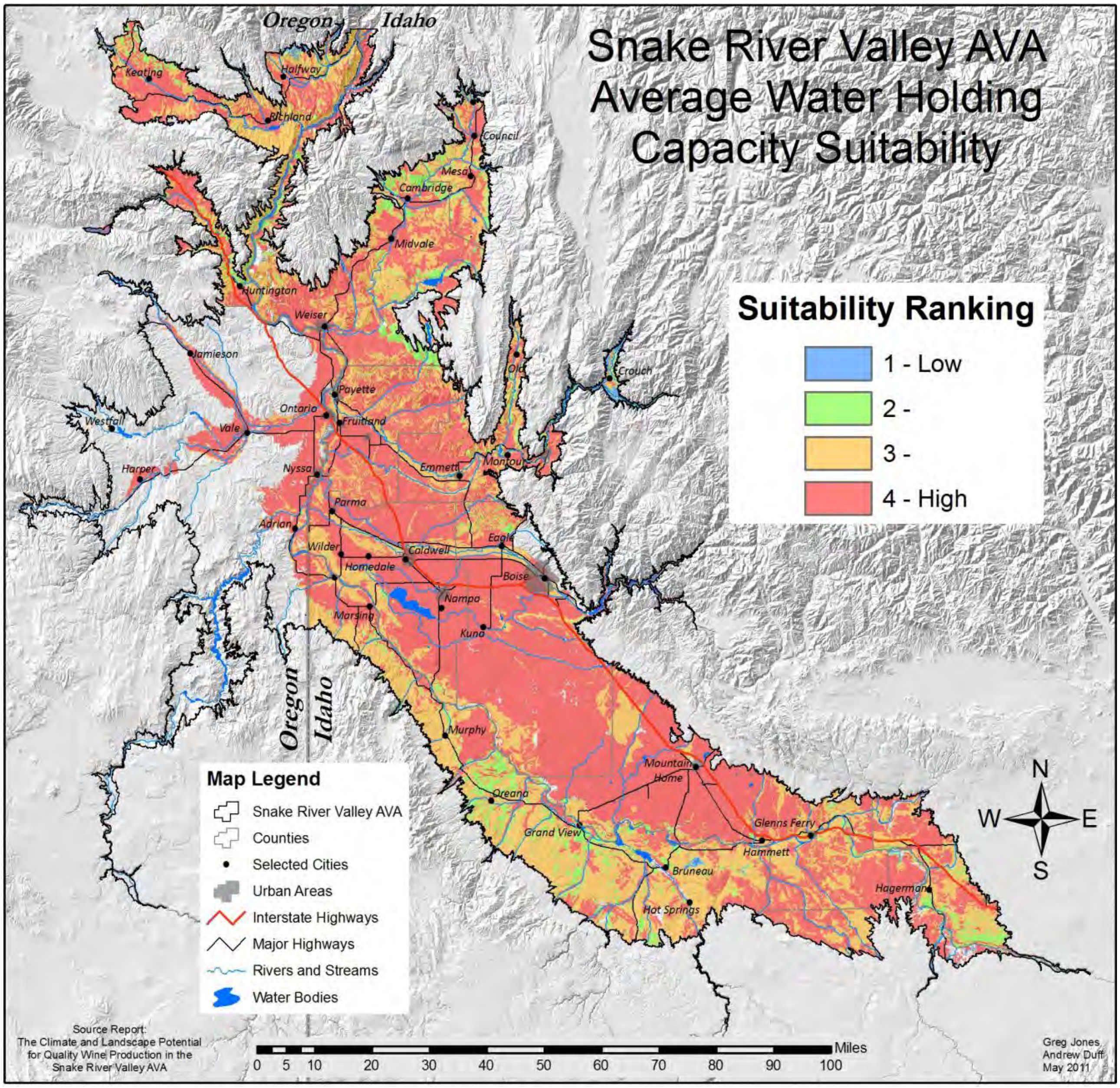

Figure 27 – The Snake River Valley AVA soil available water holding capacity classes (low to high AWC) suitability for viticulture based on the criteria given in Table 10 and described in the text. (Source: NRCS, 2010).

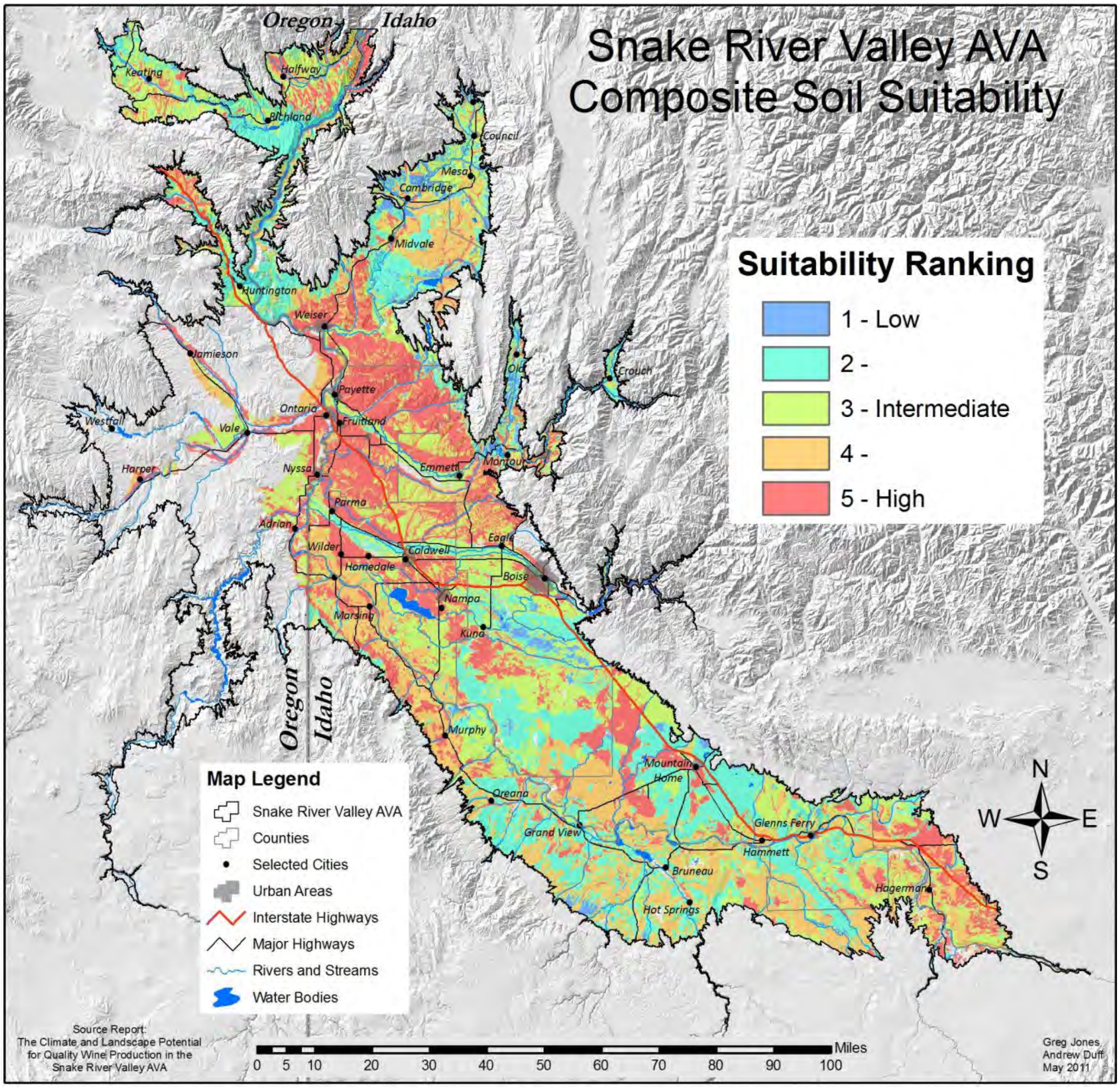

Figure 28 – The Snake River Valley AVA combined soil suitability for viticulture derived from the combination of drainage, depth to bedrock, pH, and available water holding capacity (Table 10 and Figures 24-27). (Source: NRCS, 2010).

Table 14 – Combined soil suitability based on the spatial distribution of the SSURGO data for the Snake River Valley AVA shown on the map in Figure 28 (NRCS, 2010).

Suitability	Hectares
Low Suitability	71,215
-	418,816
Intermediate Suitability	381,311
-	359,847
High Suitability	418,625
Total	*1,649,814*

Merging the overall topographic suitability (Figure 23; Table 13) with the overall soil suitability (Figure 28; Table 14) provides an overview of the composite landscape suitability of the Snake River Valley AVA (Figure 29). Intermediate to high suitability is found throughout the AVA with the highest suitability accounting for over 30,000 hectares (Table 15). In Oregon, zones of high composite landscape suitability can be found surrounding Halfway, in the Powder River Valley near Keating, along the Burnt River northwest of Huntington, west of Ontario along the Malheur River to Vale and into Harper Valley, and up the Willow Creek just past Jamieson (Figure 29). In Idaho a broad area

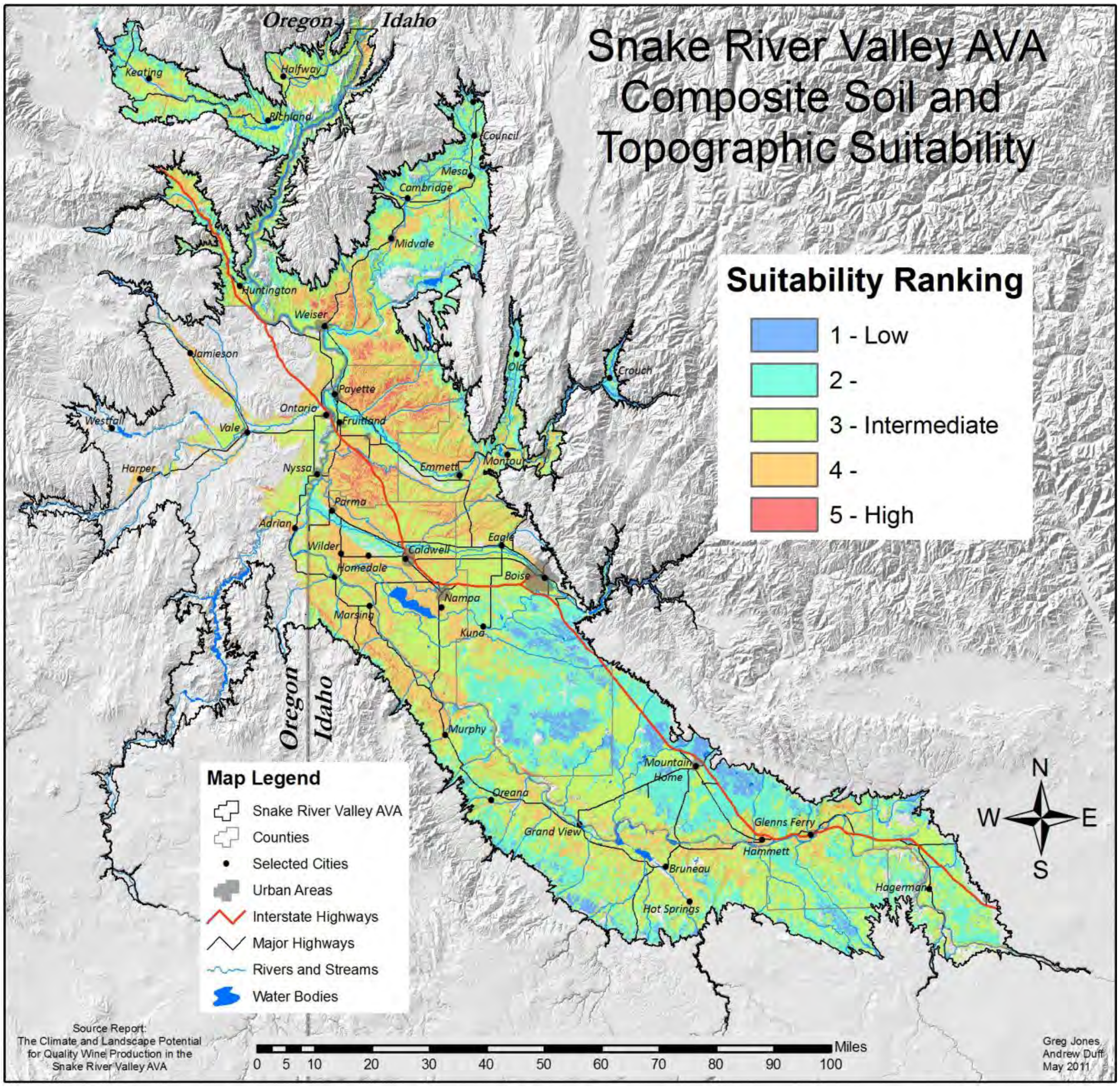

Figure 29 – The Snake River Valley AVA composite topographic and soil suitability for viticulture. (Data Sources: USGS, 2010; NRCS, 2010).

of the highest composite landscape suitability can be found from near Midvale to Weiser and south-southeast to Payette and Emmett (Figure 29). Crossing areas along the Payette and Boise rivers that have lower suitability, this zone continues in the uplands across the Treasure Valley from Fruitland to

Parma and east toward Caldwell and Eagle, then from Deer Flat and Wilder southeast past Homedale, Nampa, and Kuna. An area of generally suitable landscapes continues along both sides of the Snake River from Adrian, Oregon past Marsing and southeast past Murphy to Sinker Creek. Further along the Snake River from Sinker Creek south and east to Glenns Ferry and Kings Hill, then south to Hagerman and Buhl there are scattered good to very good landscapes (both north and south of the river) (Figure 29).

Table 15 – Composite topography and soil suitability (elevation, slope, solar illumination, drainage, depth to bedrock, pH, and available water holding capacity) derived from the regional DEMs and SSURGO data depicted in the map in Figure 18 for the Snake River Valley AVA.

Suitability	Hectares
Low Suitability	87,103
-	415,828
Intermediate Suitability	653,230
-	389,710
High Suitability	31,675
Total	*1,577,546*

Land Use Characteristics and Suitability:

Assessing land use over an area of this size is difficult as numerous agencies, counties and municipalities have different zoning criteria. However, understanding land availability for agriculture and being able to use some criteria to help map general suitability is needed. Using the Protected Areas Database for the United States from the Conservation Biology Institute (CBI, 2010) provided a measure of accounting for available land for agriculture/viticulture. The data for the Snake River Valley AVA shows that 52.5% of the area is in the ‘private lands’ matrix (just over 1.1 million hectares), while just over 43% of the land is Federal, state and local government lands make up less than 4%, and private conservation lands make up less than 1% (Table 16). As Figure 30 shows, these lands are generally scattered through the AVA, with the majority of the Treasure Valley and other highly suitable landscapes for viticulture (Figure 30) in the private land category of land ownership. The private lands are further used to mask the landscape and soils suitability grids (see below).

Table 16 – Percentage of land in the Snake River Valley AVA that is within the ownership categories given in the Protected Areas Database for the United States from the Conservation Biology Institute and mapped in Figure 30 (CBI, 2010).

Ownership Type	% of AVA
Federal Lands	43.1
Local Government Lands	< 1.0
Private Conservation Lands	< 1.0
State Lands	3.7
Private Lands	52.5
Unknown	< 1.0

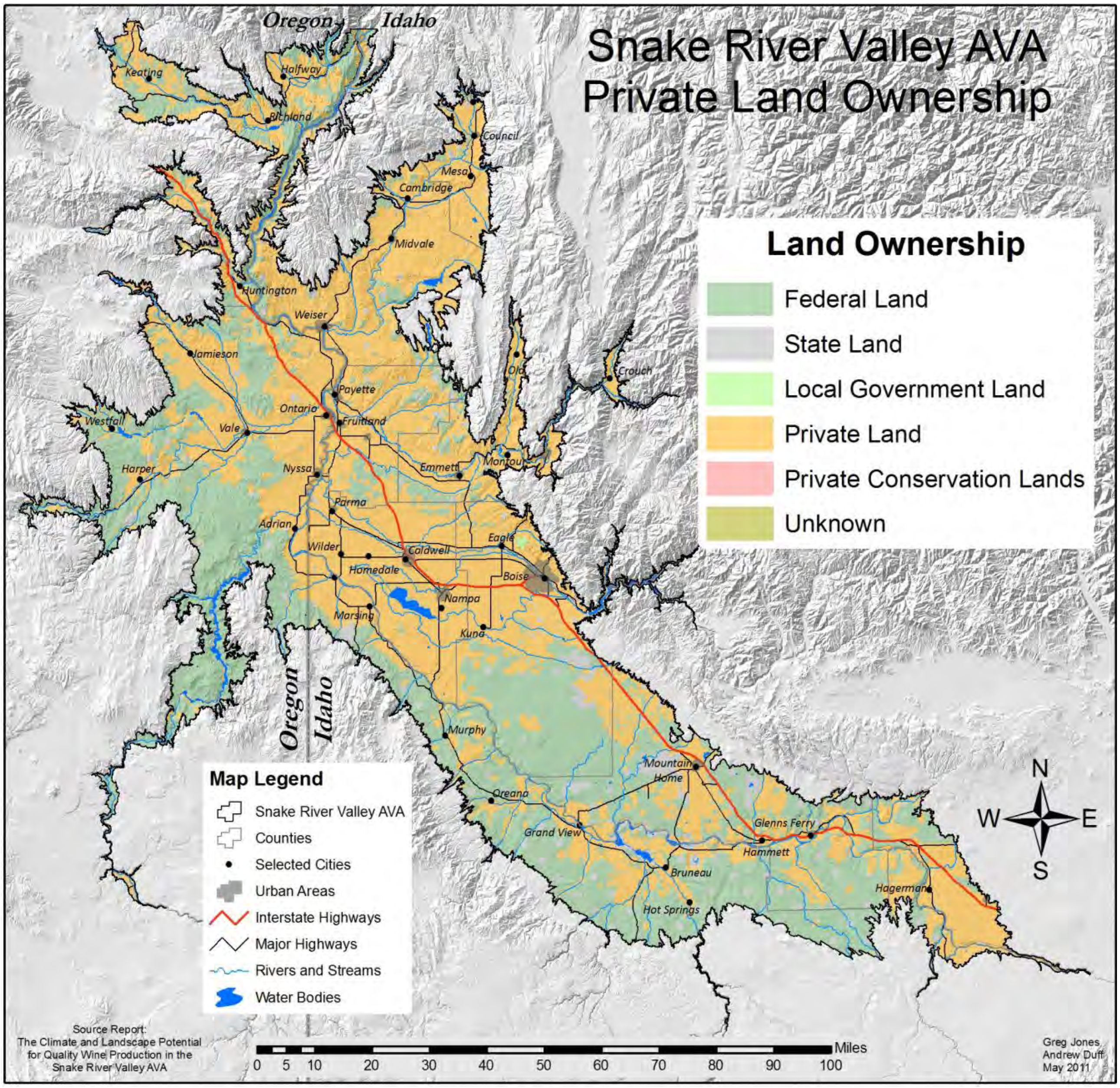

Figure 30 – The Snake River Valley AVA zoning suitability for agriculture/viticulture. Suitability criteria are based on those lands that are in private ownership (see text for more details). (Data Source: CBI, 2010).

Climate Suitability and Risk:

Climate parameters important for viticultural suitability show important spatial and elevational limits across the Snake River Valley AVA (Figures 4-13). As discussed previously, GDD averages 2392 (Region Ib) over the entire AVA with the spatial pattern showing a minimum of 1500-1600 in the upper elevations in Oregon (NW portion of the AVA) and upper elevations in the river valleys to the north and east in Idaho, to a maximum of 3100-3300 (Region III) along the Snake River to the east of the town of Murphy (Figure 8).

Examining the overall risk associated with spring and fall frost and the length of the frost-free period Figure 31 reveals that approximately 2% of the land area in the Snake River Valley AVA

(~49,000 hectares) has relatively low risk (lowest three classes). These low risk areas are found along the Snake River from Castle Creek northwest of Grand View to just northwest of Marsing and in several upland areas in Oregon, along the Snake River near Huntington, and southeast of Halfway. These upland areas are likely zones where thermal inversions are prominent, moderating the frost

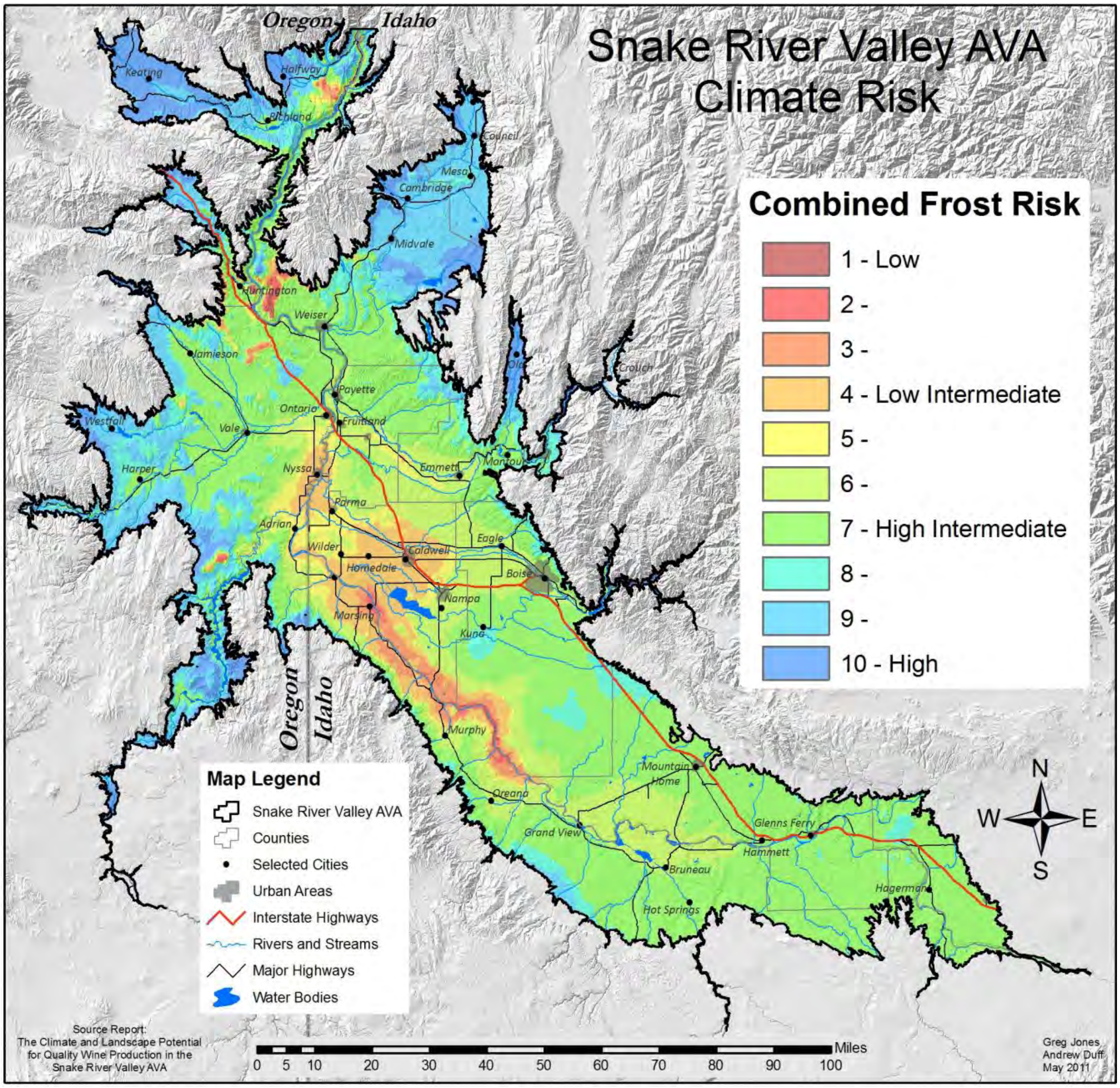

Figure 31 – The Snake River Valley AVA combined risk of frost. Low risk areas have the longest frost-free periods and lowest risk of spring and fall frosts relative to the growth cycle of grapevines (dates based on 32°F; 1971-2000 Climate Normals). (Data Source: Daly et al. 2001).

timing and frost-free period from the surrounding landscape (Figure 31). Low intermediate risk (next three classes) is depicted over a broad area from Hammett, along the Snake River up to Payette, and across the Treasure Valley upland zones (~20% of the AVA). High intermediate to high risk (four highest classes) is found typically with higher elevations, especially in the smaller river valley extensions in the western, northern, and northeastern portions of the AVA.

Overall Suitability for Viticulture and Winegrape Production:

Combining the composite landscape suitability (topography and soil), with a mask of appropriate land use zoning criteria, and then climate suitability (GDD) produces a range of suitable lands across four climate zones (Figure 32; see the Appendix for an indexed Mapbook at a larger scale). These climate zones include very cool suitability (Region Ia: 1500-2000 GDD), cool suitability (Region Ib: 2000-2500 GDD), intermediate suitability (Region II: 2500-3000 GDD), and warm suitability (Region III; 3000-3500 GDD). Note that areas within the Snake River Valley AVA in grey are due to one more of three different issues: 1) the lack of SSURGO data in much of the area in Oregon south of Huntington resulting in the areas left out of the final model, 2) being masked out by federal, state, local, and conservation lands that would theoretically not be developable into agriculture, and/or 3) simply not suitable in either topography, soil, or climate.

Very cool climate suitability (blue in Figure 32) is isolated mainly in the upper reaches of many of the tributary river valleys. These include the Burnt River northwest of Huntington, the Powder River northwest of Keating, the uplands in and around Halfway, the headwaters of the Weiser River north of Council, uplands to the south and east of Midvale, north of Ola on the Squaw Creek, in the higher elevations around the middle and south forks of the Payette River, and up the Boise River. Within the very cool group there is nearly 9,000 hectares in the two highest composite landscape suitability classes (topography and soil) (Table 17).

Table 17 – Composite landscape suitability (Figure 29, Table 18) masked by 'private lands' that are potentially suitable for agricultural development (Figure 30, Table 19) and classed by growing degree-days regions (Figure 8) in the Snake River Valley AVA.

Suitability Within Climate Groups (hectares)	Very Cool Region Ia (1500-2000)	Cool Region Ib (2000-2500)	Intermediate Region II (2500-3000)	Warm Region III (3000-3500)	Totals
Low Suitability	5,707	22,104	3,470	10	*31,291*
-	18,257	108,402	66,072	13	*192,744*
Intermediate Suitability	22,226	168,629	188,984	37	*379,876*
-	8,788	101,761	175,341	17	*285,907*
High Suitability	177	9,960	11,487	0	*21,624*
Total	*55,155*	*410,856*	*445,354*	*77*	*911,442*

Cool climate suitability (green in Figure 32) is more widely spread throughout the Snake River Valley AVA with most areas at elevations just lower than the very cool class, especially along the northern portion of the Snake River, in the foothills above the Treasure Valley (the unwooded alkaline foothills and semiarid foothills ecoregions in Figure 3), other southeastern sections of the Snake River, and scattered over the Mountain Home upland ecoregion south and east of Boise (Figure 32). There are over 100,000 hectares in the two highest composite landscape suitability classes, and nearly 10,000 hectares in the highest class (Table 17).

Intermediate climate suitability (orange in Figure 32) encompasses many landscapes occurring at slightly lower elevations than the cool class with the vast majority occurring throughout the Treasure Valley ecoregion (Figure 3) and scatter areas along the Snake River near Murphy, Grand View, Bruneau, Hammett, Glenns Ferry, Hagerman, and Buhl. The mapped area of the intermediate climate suitability class covers over 11,000 acres in the highest composite landscape suitability to over 175,000 hectares in the top two classes (Table 17).

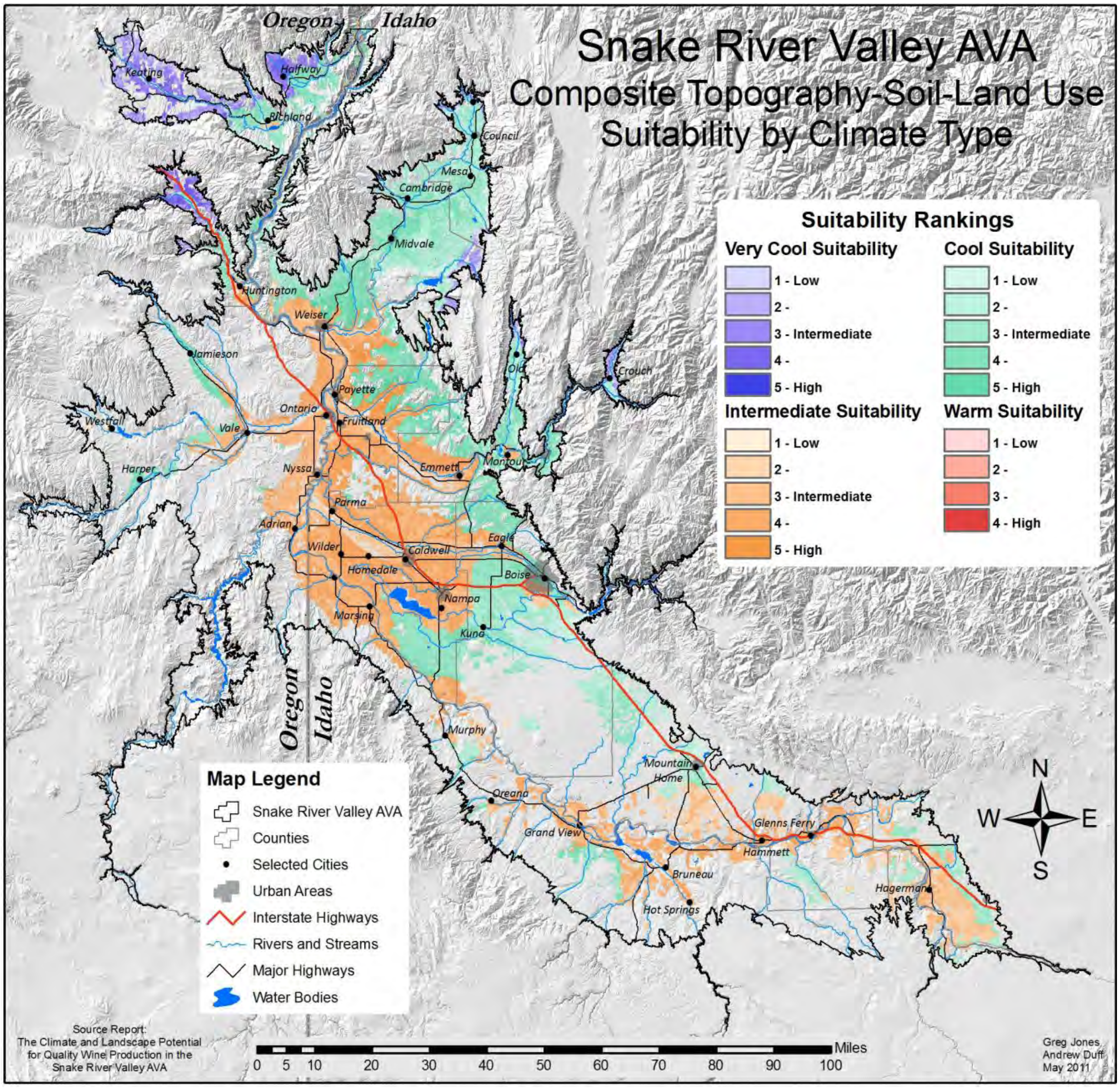

Figure 32 – Composite landscape suitability (Figure 29, Table 18) masked by 'private lands' that are potentially suitable for agricultural development (Figure 30, Table 19) and classed by growing degree-days regions (Figure 8) for the 1971-2000 Climate Normals in the Snake River Valley AVA. The low to high suitability shading depicted in the legend results from variations in suitability in topography and soil. (See the Appendix for an indexed Mapbook at a larger scale)

Warm climate suitability (red in Figure 32) is very limited over the Snake River Valley AVA with only a small area of just under 100 hectares east of Murphy near Swan Falls (See Mapbook page 23 in the Appendix). None of this area is found in the highest composite landscape suitability, but over 50 hectares are found in the next two classes (Table 17). It is important to note that the 1971-2000 Climate Normals data used for this assessment are cooler than the 1981-2010 Climate Normals, but unfortunately the later normals were not available as spatial data for this analysis. However, comparing Figures 8 and 9 gives some indication of the general spatial changes one could expect over the Snake River Valley AVA. Furthermore, Table 5 shows decreases in the area in the very cool and cool suitability classes (Regions Ia and Ib), increases in the area of the intermediate and warm climate suitability classes (Regions II and III), and some areas that have moved into the very warm climate suitability class (Region IV; same area near Swan Falls).

Figure 33 combines the general climate-landscape suitability in Figure 32 with the risk mapped for late spring and early fall frosts and too short of growing seasons in Figure 31. The contours in Figure 33 encompass the lowest risk (red contour, first three classes in Figure 31) and moderate risk

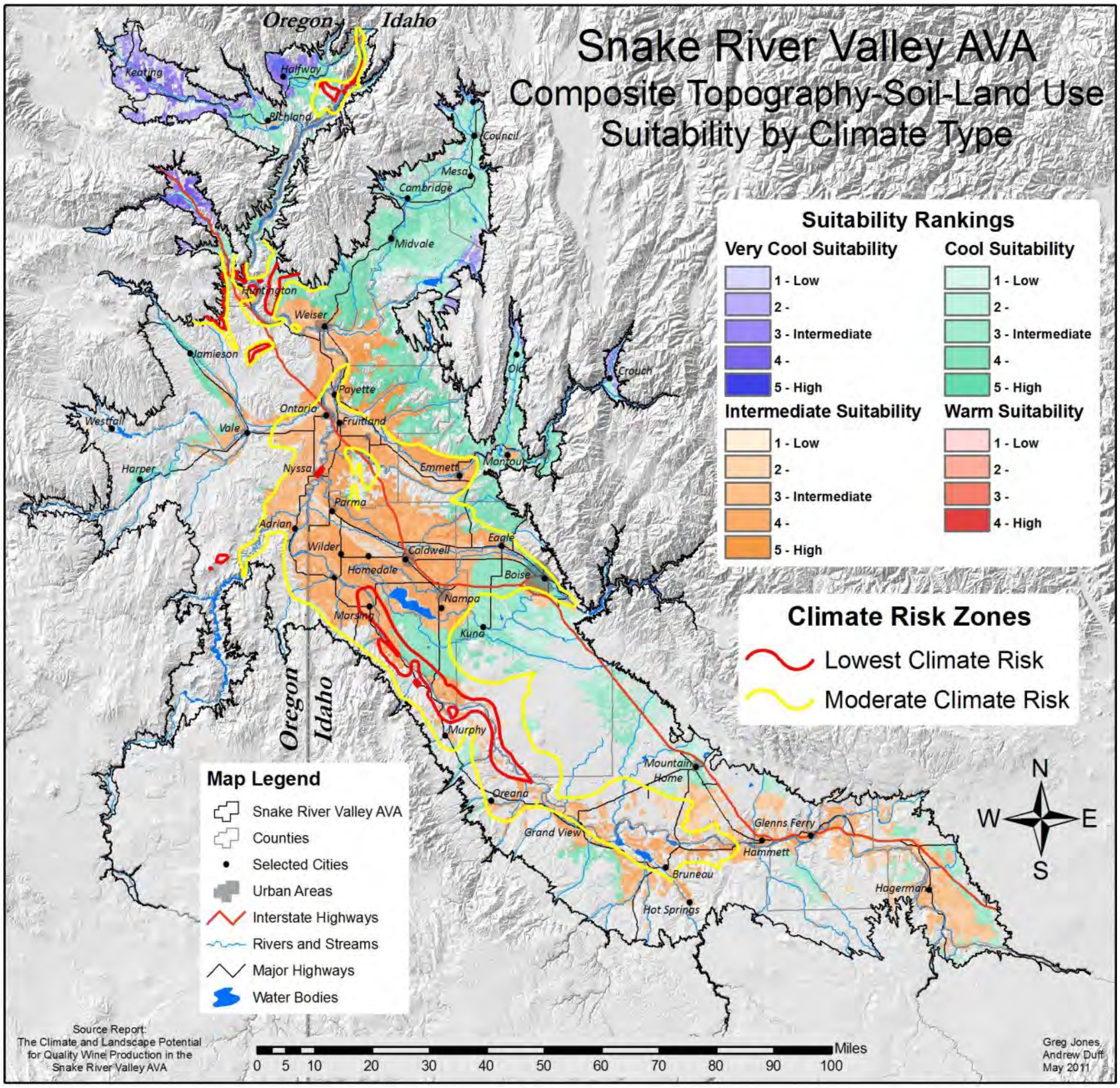

Figure 33 – Same as Figure 32, but overlain with climate risk zones (spring and fall frost, frost-free period) from Figure 31. The lowest climate risk contours (red contours) are the lowest three classes and the moderate climate risk contours (yellow contours) are the next three classes from Figure 31.

(yellow contour, next three classes in Figure 31). All areas outside these two contours have moderate to relatively high risk due to short growing seasons, late spring frosts, or early fall frosts. The lowest risk zones (red contour) can be found in areas along the Snake River southeast of Halfway and in and around Huntington and in a broad zone from the Sunnyslope area northeast of Marsing along the Snake River southeast to Castle Butte (Figure 33). A broad zone of intermediate risk (yellow contour) is found over most of the Treasure Valley ecoregion from north of Payette to southwest of Adrian along the Owyhee River, across to just southeast of Boise, and along the Snake River southeast to near Hammett.

Existing Vineyards and Comparisons to Zoning Results:

During 2009-2010 a grower survey was conducted by Boise State University. The survey was designed to capture location and growing information associated with existing vineyards and to compare the characteristics with the zoning model for suitability presented previously. The survey started with a list of growers from the Idaho Wine Commission who were contacted and asked to participate in the survey. The survey included using GPS to capture the vineyard blocks along with questions related to the varieties planted, the type of vine training system used, the planting spacing (row and vine) and the type and source of irrigation used. Vineyards were also assessed for the row orientation and aspect of the block. The vineyard blocks were then summarized by both the survey data and the spatial data used in the zoning model discussed in the previous section (e.g., topographic parameters, soil parameters, climate parameters, etc.).

A total of 53 vineyards were surveyed representing 1240 acres (Table 18). The vineyards range from just under one acre to nearly 400 acres with a median vineyard size of 8.5 acres. The majority of the vineyards and acreage are principally located from just southwest of Parma, southeast across Sunnyslope to Marsing and southeast to Kuna (Figure 34). Surveyed vineyards can also be found between Caldwell and Eagle, near Payette, Vale, and Emmett, between Hammett and King Hill, and near Hagerman and Buhl in the southeast portion of the AVA.

Survey respondents indicated that nearly 40 varieties are planted in the region with six varieties having 50 acres or more (Table 18). At 344 acres and 28% of the acreage, Riesling is the most widely planted cultivar while Chardonnay, Cabernet Sauvignon, and Merlot represent from 10-15% of the total planted acreage. Many survey respondents reported blocks with mixed varieties (136 acres and 11% of the planted area) and a few indicated table grape plantings (9 acres). On average, growers reported that their vines are planted to 6 foot vine to vine spacing and 10 foot row to row spacing, however vine to vine spacing ranges from 5.0 to 10.0 feet, while row to row spacing ranges from 6.5 to 13.0 feet. The rows are largely north-south oriented (74% of all acreage) with the rest of the acreage oriented east-west (20%), northeast-southwest (4%), and southeast-northwest (2%). The trellis systems most commonly used by the surveyed vineyards are a single-trunk VSP (50% of all acreage) or a double-trunk VSP (43%) while 7% used various other trellis systems (e.g., Sylvoz, etc.) or were head-pruned. The trellis systems employed use from one to five wires, with a five wire trellis system being the most common and being used on 39% of the acreage. Just over 38% of the acreage has three moveable wires while 31% of the acreage has fixed wires. Irrigation was reported to be used on all of the 1240 acres with nearly 70% of the acreage using a drip system, 20% in a variable system (multiple methods), 4% in overhead sprinklers, 6% under flood irrigation, and less than 1% each for gravity and micro-misters. The source of the irrigation water was predominately canal (irrigation district) at 56%, with 10% indicating a well source and 34% not specifying a source.

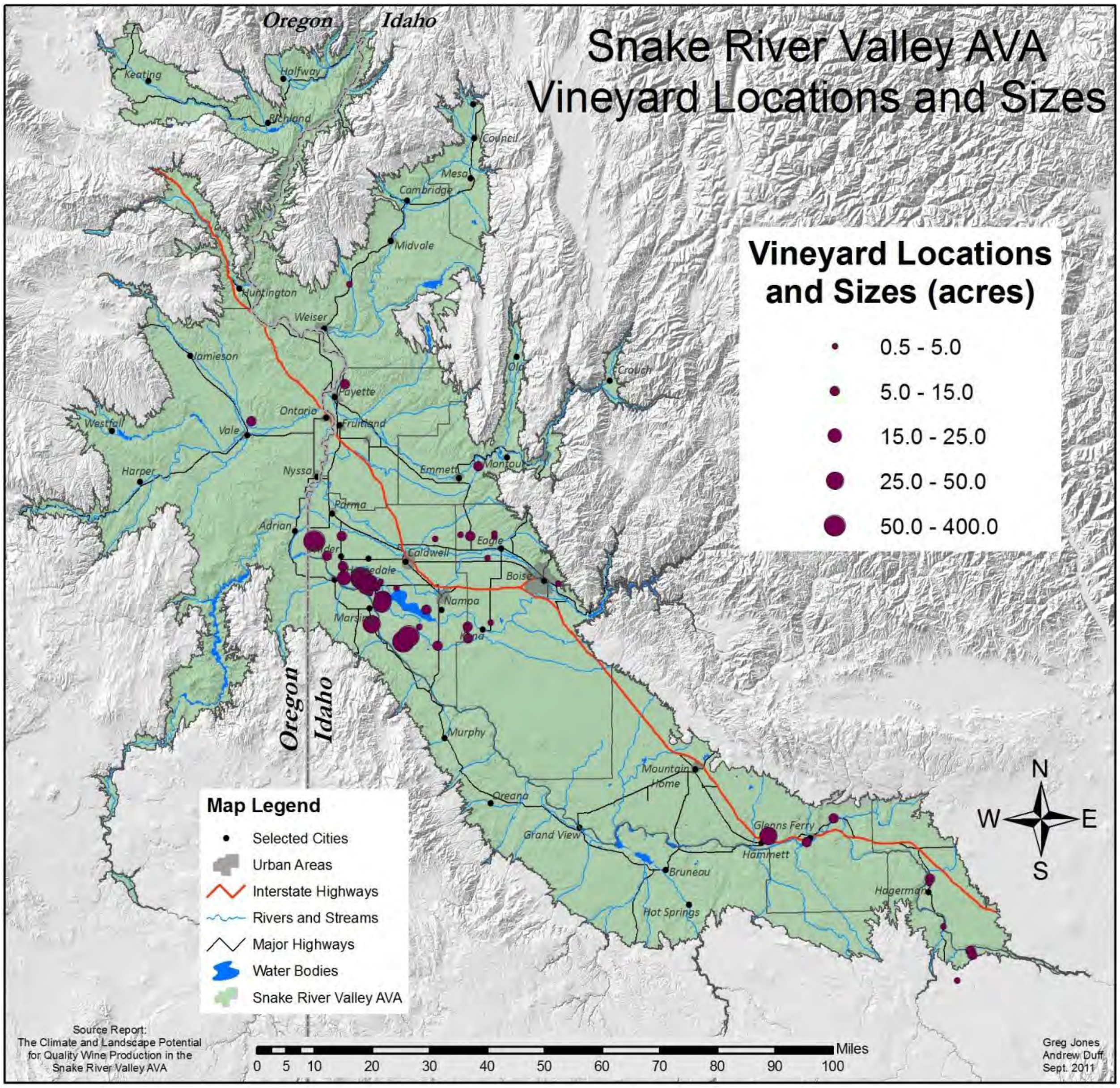

Figure 34 – Locations and sizes of the 53 vineyards in the Snake River Valley grower survey.

Using the region wide digital elevation model (DEM) from the zoning assessment the surveyed vineyard elevations, slopes, and aspects can be determined. The surveyed vineyards are found at a median elevation of 2618 feet, ranging nearly 1500 feet from a low of 2190 feet to high of 3688 feet (Table 19). The within vineyard block elevation range is from just below 5 feet to nearly 300 feet (not shown). Vineyard slopes in the region range from essentially flat to 33% with a median of 5.4% across all sites. A total of 69% of the vineyards have average aspects (slope exposure) from SE (19%), to S (22%), and to SW (28%) with an overall median of southerly aspects (182°). However, within vineyard range in aspects can vary over 180 degrees of exposure.

Table 18 – Existing vineyard survey responses for varieties and acreage planted.

Variety	# of Vineyards Growing the Variety	Reported Acreage	% of all Planted Acreage
Riesling	37	344.0	27.7
Chardonnay	36	181.8	14.7
Cabernet Sauvignon	41	174.8	14.1
Mixed*	30	136.5	11.0
Merlot	40	126.0	10.2
Syrah	22	63.1	5.1
Gewürztraminer	12	51.8	4.2
Cabernet Franc	9	30.0	2.4
Pinot Noir	7	24.4	2.0
Sauvignon Blanc	5	21.3	1.7
Viognier	16	14.8	1.2
Petit Verdot	7	10.6	0.9
Malbec	6	9.9	0.8
Table Grapes	9	8.9	0.7
Muscat	5	8.2	0.7
Pinot Gris	6	6.0	0.5
Tempranillo	9	5.8	0.5
Lemberger	3	5.5	< 0.5
Mouvèdre	4	3.9	< 0.5
Petit Syrah	3	3.5	< 0.5
Semillon	10	2.9	< 0.5
Sangiovese	1	1.5	< 0.5
Primativo	2	1.1	< 0.5
Grenache	2	1.0	< 0.5
Port	2	1.0	< 0.5
Cinsault	2	0.6	< 0.5
Tannat	1	0.4	< 0.5
Pinot Meunier	1	0.3	< 0.5
Carménère	2	0.3	< 0.5
Sousão	2	0.2	< 0.5
Zinfandel	1	0.1	< 0.5
Mourvèdre	1	0.1	< 0.5
Barbara	1	0.1	< 0.5
Rousanne	1	0.1	< 0.5

* Survey respondents did not indicate individual varieties.

Table 19 – Summary statistics for site parameters averaged over the surveyed vineyards.

Parameter	Mean	Median	Std. Dev.	Max.	Min.	Range
Elevation (ft.)	2648	2618	266	3688	2190	1498
Slope (%)	5.8	5.4	3.9	32.8	Flat	32.8
Aspect (degrees)	170	182	73	294	Flat	294
Available Water Capacity (in./in.)	0.15	0.16	0.04	0.20	0.07	0.13
Soil pH	7.52	7.54	0.39	8.50	6.70	1.50
Depth to Bedrock (in.)	40.1	41.4	9.7	152.0	8.0	144.0
Growing degree-days (F°)	2543	2534	112	2849	2313	536
Annual Precipitation (in.)	10.6	10.3	1.5	18.1	8.8	9.3
Last Spring Frost (date/days)	5 May	4 May	6 days	18 May	26 Apr	22 days
First Fall Frost (date/days)	7 Oct	6 Oct	4 days	10 Oct	25 Sep	14 days
Frost Free Period (days)	152	154	9 days	167	130	37

Examining soil types and characteristics from the SSURGO soils data (NRCS, 2010) for the 53 surveyed vineyards finds that the sites are mapped to 51 different soil series or complexes (Table 20). However, 30 of the soil types are mapped to less than 10 acres each leaving the vineyards mostly planted to 20 main soil series or complexes. The Scism silt loam soil makes up just over 27% of the total planted acreage (338 acres). Other prominent soils are the Turbyfill fine sandy loam (16% of the total acreage), Jacquith loamy fine sand (8%), Truesdale fine sandy loam (7%), Feltham loamy fine sand (5%), and Bahen silt loam (5%) (Table 20). The median available water capacity (AWC) of the soils over all surveyed vineyards is 0.16 inches of water per inch of soil with a range from 0.07 to 0.20 (Table 19). Soil pH over the surveyed acreage averages 7.5 with a range from 6.7 to 8.5. Estimated depth to bedrock in the SSURGO data for the surveyed vineyards ranges from a low of 8 inches (isolated zone or outcrop in a vineyard block) to over 150 inches with a median of 41 inches (Table 19). In terms of drainage, the surveyed vineyards show the prominent silty to sandy loam soil types found in the region with mostly low to moderately low runoff potential and moderate to rapid water transmission through the soil (not shown). However, some sites do have blocks or zones within blocks that are mapped as having moderate to high runoff potential with restricted water movement through the soil.

Table 20 – The NRCS soil series found in the surveyed vineyard blocks (NRCS, 2010).

NRCS Soil Series	# of Vineyards with the Soil Type	Acreage with that Soil Type	% of all Planted Acreage
Scism Silt Loam	6	337.7	27.3
Turbyfill Fine Sandy Loam	6	196.2	15.9
Jacquith Loamy Fine sand	2	93.9	7.6
Truesdale Fine Sandy Loam	3	88.8	7.2
Feltham Loamy Fine sand	5	64.5	5.2
Bahem Silt Loam	4	62.0	5.0
Trevino Silt Loam	2	48.5	3.9
Elijah Silt Loam	4	30.2	2.4
Royal Fine Sandy Loam	2	28.5	2.3
Cencove Fine Sandy Loam	3	24.1	1.9
Rock outcrop - Trevino Complex	3	22.3	1.8

NRCS Soil Series	# of Vineyards with the Soil Type	Acreage with that Soil Type	% of all Planted Acreage
Badland-Typic Complex	1	21.8	1.8
Escalante-Tindahay-Ornea Complex	1	21.1	1.7
Terrace Escarpments	2	18.2	1.5
Power Silt Loam	4	17.5	1.4
Nyssaton Silt Loam	4	15.5	1.3
Buko Fine Sandy Loam	2	15.2	1.2
Vickery-Marsing Silt Loams	2	14.8	1.2
McKeeth-Veta Gravelly Loam	1	13.8	1.1
Minidoka-Scism Silt Loams	2	10.7	< 0.01
Harpt Loam	1	10.1	< 0.01
Gravel Pit	3	8.2	< 0.01
Vanderhoff Loam	2	6.9	< 0.01
Timmerman Sandy Loam	1	6.4	< 0.01
Cashmere Sandy Loam	1	5.9	< 0.01
Purdam Silt Loam	2	5.7	< 0.01
Nyssa Silt Loam	1	5.2	< 0.01
Newell Clay Loam	1	4.6	< 0.01
Garbutt Silt Loam	2	4.4	< 0.01
Starbukc-Lava Flows Complex	1	3.7	< 0.01
Greenleaf-Owyhee Silt Loams	3	3.4	< 0.01
Owyhee Silt Loam	2	3.3	< 0.01
Lankbush-Brent Sandy Loam	1	3.1	< 0.01
Minidoka Silt Loam	2	3.1	< 0.01
Kecko Fine Sandy Loam	2	3.0	< 0.01
Minveno Silt Loam	1	2.3	< 0.01
Marsing Loam	1	2.2	< 0.01
Power-Purdam Silt Loams	3	2.0	< 0.01
Paniogue Loam	1	1.7	< 0.01
Rakane-Blacknest Complex	1	1.6	< 0.01
Cowgil Extremely Stony Sandy Loam	1	1.0	< 0.01
Lankbush-Power Complex	1	0.6	< 0.01
Harpt Coarse Sandy Loam	1	0.4	< 0.01
Kudlac Silty Clay	1	0.4	< 0.01
Antelope Springs Loam	1	0.3	< 0.01
Sluka Silt Loam	1	0.3	< 0.01
Ephrata Fine Sandy Loam	1	0.2	< 0.01
Feltham-Quincy Complex	1	0.2	< 0.01
Davey-Buko Complex	1	0.2	< 0.01
Jenness Loam	1	0.2	< 0.01
Tindahay Fine Sandy Loam	1	0.1	< 0.01

Using the PRISM 1971-2000 Climate Normals to summarize the surveyed vineyard climate finds that the 53 sites have annual precipitation values that range from 8.8 to 18.1 inches, with a median of 10.3 inches (Table 19). Growing degree-days over all sites averages 2543 and ranges from a low of 2313 to a high of 2849. From a frost perspective the median last spring date is May 4th with a 22 day window from the earliest median date of April 26th to the latest median date of May 18th (Table 19). The median date of the first fall frost has a 14 day window over all locations and averages October 6th with the earliest median date being September 25th and the latest median date of October 10th. The resulting frost-free period has an overall vineyard average of 154 days, ranging 30 days from the shortest at 130 days to the longest at 167 days (Table 19).

The vineyard block boundaries were also used to compare the zoning model output (discussed in previous sections) with existing sites. Examining the combined topographic suitability (elevation, slope, and solar receipt) the 53 vineyards averaged 4.0 out of a total possible score of 5.0, but ranged from very low suitability (1.2 out of 5.0) to what could be considered an ideal landscape for viticulture (5.0 out 5.0, at a few sites) (Table 21). Overall, the majority of the surveyed vineyards are sited at locations that would be considered to have intermediate to good suitability (51% of the acreage scores between 3.0 and 4.0) in terms of elevation, slope, and solar receipt while 45% of the acreage would be considered very good to exceptional sites (scores between 4.0 and 5.0) However, it should be noted that within vineyard variability on the combined topographic suitability is evident with some sites showing a range of three suitability points over the blocks in a single vineyard.

In terms of soil suitability, the surveyed vineyards scored an average of 3.8 out of 5.0 on the combined drainage, depth to bedrock, pH, and available water capacity suitability (Table 21). The site averages ranged from a low of 2.1 to a high of 5.0, but within block variation in soil suitability is evident with many vineyards showing a range in the overall score from 3.0 to 4.0. No vineyards were found on the two lowest suitability classes, while 18% of the acreage scored in the intermediate soil suitability (2.0-3.0), 64% in the good suitability class (3.0-4.0), and 18% in the very good to exceptional class (4.0-5.0).

Table 21 – Summary statistics for the suitability scores averaged over the surveyed vineyards.

Suitability	Mean	Median	Std. Dev.	Max.	Min.	Range
Topographic*	3.8	4.0	0.8	5.0	1.2	3.8
Soil*	3.7	3.8	0.9	5.0	2.1	2.9
Composite Landscape*	3.5	3.6	0.6	5.0	2.0	3.0
Climate Risk§	5.4	6.0	1.4	8.0	3.0	5.0

* These suitability criteria are scored on a 1 (low suitability) to 5 (high suitability) scale.
§ Climate risk criteria is scored on 1 (low risk) to 10 (high risk) scale.

The combined landscape suitability (topographic and soil) for the surveyed vineyards shows that they score an average 3.6 out of 5.0 (Table 21). The vineyard average scores range from a low of 2.0 to a high of 5.0, with a similar within block range of up to four classes (low to exceptional suitability across individual sites). The distribution across the five suitability classes finds that no vineyards scored over the two lowest classes, 11% of the acreage is scored as intermediate suitability (2.0 to 3.0), 69% of the acreage as good suitability (3.0 to 4.0), and 21% in the very good to exceptional class (4.0 to 5.0).

For the growing degree-day classes given in Table 1, 15 of the 53 surveyed vineyards are in Region Ib and 38 of the vineyards are in Region II. However by acreage the surveyed vineyards are evenly split with 50% of the acreage in Region Ib and 50% in Region II for the 1971-2000 Climate Normals. For climate risk associated with late spring frosts, early fall frosts, and the length of the frost-free period, the surveyed vineyards scored 5.4 out of 10.0, or having on average an intermediate risk situation (Table 21). The locations ranged from a low of 3.0 (low risk) to 8.0 (high risk). Of the total acreage surveyed, 77% has low intermediate to intermediate risk (scoring 3.0 to 5.0), while 23% has moderate to high risk (scoring 5.0 to 8.0).

Conclusions:

Crop suitability to the environmental conditions in a given region is the most pervasive factor in the success of all agricultural systems, largely controlling crop production and quality, and ultimately driving economic sustainability. These influences are never more evident than with viticulture and wine production where climate, topography, soil, and how they are chosen and managed by growers are the most critical aspects in ripening fruit to optimum characteristics to produce a given wine style. However, the choice of the best site or the most suitable variety to a given site is often conducted via limited experience or information, or through trial and error, which often increases the vulnerability of the operation and, if widespread, limits the wine quality recognition of the region.

The Snake River Valley of Idaho is a young winegrowing region which has grown out of the state's rich agricultural heritage beginning with the arrival of immigrants who settled the west. Today Idaho ranks 23rd in the United States in the total value of all agricultural products sold ($5.7 billion; USDA, 2010). In the United States, Idaho ranks 1st in potatoes, 2nd in vegetables, 3rd in barley, 11th in wheat, and 18th in forage (hay and other forage products). At the state level potatoes are the number one crop followed by wheat, hay and alfalfa, then numerous grains, dry beans, lentils, and peas, followed by peppermint, and hops. However, over the last decade winegrapes have been one of the fastest growing agricultural commodities becoming the 2nd largest fruit crop in the state, representing 18% of the total acreage (USDA, 2006). Established in 2007, the Snake River Valley American Viticultural Area (AVA) (Figure 1) encompasses approximately 8,263 square miles over the Western Snake River Plain of Idaho and Oregon. Today there are at least 60 vineyards consisting of 1600 or more acres, providing fruit to over 40 wineries which crushed over 3000 tons and made over 200,000 cases in 2009. The goals of this research were to further support this growth and help the industry further realize it's potential by examining the viticultural suitability of the landscape and climate in the Snake River Valley AVA.

The result of the terroir zoning for the region finds that approximately 6% of the AVA (135,000 hectares) has excellent topographic suitability (a combination of elevation, slope, and solar illumination). Soils in the Snake River Valley AVA strongly reflect the underlying geology and show characteristics of internal drainage, depth, pH, and available water capacity over the region that appear to be very good for viticulture. The composite soil suitability depicts approximately 20% of the AVA (420,000 hectares) as having soils conducive to viticulture. A combination of topographic and soil suitability reveals that the AVA has just over 30,000 hectares of land (1.5% of the AVA) that has very good to exceptional landscapes for viticulture. While assessing land use issues is more problematic due to the myriad of data sources, types, and criteria, the analysis of the Protected Lands Database (CBI, 2010) shows that just over 50% of the AVA is in a 'private lands' matrix (just over 1.1 million hectares), which theoretically would be available for an agricultural enterprise or could be developed as such. From a climate perspective, the baseline suitability of the AVA shows a cool to warm climate growing environment with the region experiencing 1500-3300 growing degree-days. An analysis of climate risk (spring and fall frost and the length of the frost-free period) shows that roughly 2% of the AVA has relatively low risk, although the frost-free period is relatively short over the majority of the AVA. The warmest and least risky areas are those along the Snake and Payette rivers from just north of the town of Payette south and east across the Treasure Valley and along the Snake River toward Hammett and Glenns Ferry.

Comparing the existing vineyards with the modeled suitability zones finds overall good agreement with most locations planted on good to excellent landscapes (topography and soils). However, many vineyards show moderate to substantial within block variation in soil suitability and overall site suitability. Climatically these existing vineyards are equally divided between Region Ib and Region II for growing degree-days and exhibit low to relatively high frost risk. Given the region's current climate structure, experiences from existing growers, and variety trials at the USDA-ARS Horticultural Crops Research Laboratory at Parma (Shellie, 2007) the Snake River Valley AVA is clearly suitable to many of the varieties currently planted in the region. These would include, but are not limited to, Chardonnay, Pinot Gris, Riesling, Pinot Noir on the cooler sites; Sauvignon Blanc, Cabernet Franc, Tempranillo, and Dolcetto on the intermediate sites; and Merlot, Malbec, Viognier, Syrah, Cabernet Sauvignon, and Grenache on the warmest sites. Probably the most limiting issue is frost timing and the length of the growing season, which is relatively short over most of the AVA. This would point to choosing varieties that bud late and ripen early while needing moderate heat accumulation. The results in this assessment also provide another measure to select varieties by comparing the climate structure of any site/region with that of Parma where research by Shellie (2007) gives some indication of growth timing, fruit composition, and production levels for many varieties.

While this assessment adds to the understanding of the potential for winegrape production in the region, there are limitations to the model and further issues that each grower will need to address before developing any individual site. First, resolution limits with the elevation data mean that subtle differences within the landscape such as elevation, slope, and solar illumination variations will not be modeled perfectly. Second, the soil data has also been gathered and digitized relative to NRCS soil surveys, which do not test soils at every possible point but use spatial relationships with known characteristics of the landscape and vegetation. It is suggested that each potential grower do a qualified site soil analysis, including assessing the macro- and micro-nutrient structure, to fully understand the suitability for viticulture. Third, the climate assessment has a few important caveats. The PRISM data is a model and estimates the climate parameters over the landscape using known relationships between topography and climate. However, unique local conditions could cause the model to over or under estimate the climate grids, but large discrepancies are not expected due to the strong validation and quality control of the data (Daly et al., 2008). While the PRISM data is the highest resolution climate data product in the United States and is the USDA standard, the resolution of approximately 16 hectares is such that capturing the exact within site or block variations in GDD and frost potential is difficult. In addition, as noted in the climate summary, the use of the 1971-2000 Climate Normals likely underestimates the 1981-2010 Climate Normals by 5-15% in GDD and depicts slightly greater frost risk, therefore users should consider these issues when examining the results. Fourth, the land use and overall suitability modeling cannot tell whether a given piece of land is available or whether or not it has access to water for irrigation. Both issues will need to be addressed on a site by site basis. Finally, once the limits of any site are identified, additional questions regarding variety, rootstock, vine and row spacing or necessary amendments during the pre-plant stage should be made.

The Snake River Valley AVA is an extremely viable and promising region for winegrape production. The region's relatively short history of viticultural practices has shown the potential to ripen many cool to warm climate grape varieties. Rapid growth of the industry is likely to continue due to current successes and the availability of land. Through spatial analysis this research has helped to further define the terroir potential of grape growing in the Snake River Valley AVA. The results provide existing and future growers with baseline knowledge of the region's grape growing potential relative to its topography, soil, land use, and climate. While not specifically addressing the cultural aspects of terroir (e.g., style-directed viticultural and enological practices), which typically take many years to become dominant, the results presented here should serve to initiate better decisions in the site selection process, thus leading to fewer and/or more efficient trial and error procedures. Finally, potential growers need to be aware that the site selection process will involve compromises, in that few sites will possess ideal characteristics in every respect. While compromises will occur in many cases, this body of research presents one of the best tools yet to enhance the site selection process for future growers in the Snake River Valley AVA of Idaho.

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Appendix:

Appendix Table 1 – The Level IV ecoregions found in Idaho and Oregon and their descriptive information on physiography, geology, soils, vegetation, and dominant land use/land cover. Information sourced from (USEPA, 2000) and (McGrath et al. 2002) for Idaho and (Thorson et al. 2003) for Oregon.

ID	Ecoregion	Physiography	Geology (Surficial and Bedrock)	General Soil Order (Great Order)	Common Soil Series	Potential and Present Vegetation	Dominant Land Use and Land Cover
11d	Melange	Unglaciated. Dissected mountains.	Quaternary colluvium. Tertiary basalt with a core of Tertiary metavolcanics, volcaniclastics, and metasediments and Jurassic granitic, metasedimentary, and sedimentary rocks.	Mollisols (Haplocryolls, Argicryolls, Haploxerolls, Argixerolls)	Bluebell, Ticanot, McDaniel, Rockly	Western ponderosa pine forest, sagebrush steppe/ Douglas-fir, ponderosa pine, lodgepole pine, mountain mahogany, snowberry, serviceberry, Idaho fescue, bluebunch wheatgrass.	Partly forested. Mostly livestock grazing and wildlife habitat.
11e	Wallowas/Seven Devils Mountains	Partly glaciated. Mountains. Steep gradient streams following fault lines have steep longitudinal gradients and have eroded deep canyons.	Quaternary colluvium. Mostly Tertiary basalt with a core of Permian metavolcanic, volcanic, pyroclastic, and volcaniclastic rocks.	Mollisols (Argixerolls), Andisols (Haplocryands)	Vay, Klickson, Suloaf, Bluesprin, Gaib	Grand fir–Douglas-fir, western ponderosa pine, and western spruce–fir forests/ Douglas-fir, ponderosa pine, lodgepole pine, mountain big sagebrush, low sagebrush, Idaho fescue, bluebunch wheatgrass. Higher sites: subalpine fir.	Covered in dry forests with a shrub understory. Livestock grazing, recreation, logging, and wildlife habitat.
11f	Canyons and Dissected Highlands	Unglaciated. Deep river canyons and dissected highlands in the rain shadow of mountains.	Quaternary colluvium, alluvium and glacial deposits. Tertiary basalt. Many faults.	Mollisols (Argixerolls, Haplocryolls, Argicryolls), Alfisols (Haploxeralfs)	Suloaf, Uptmor, Telcher, Bluesprin, Klickson, Bluebell, Ticanot, Cramont	Western ponderosa pine forest/ Douglas-fir, ponderosa pine, Idaho fescue, bluebunch wheatgrass, bluegrass.	Forested. Woodland grazing, logging, recreation, and wildlife habitat.
11g	Canyons and Dissected Uplands	Unglaciated. Deep river canyons and dissected uplands.	Quaternary colluvium. Tertiary basalt and Tertiary metamorphic, metavolcanic, metasedimentary, and sedimentary rocks.	Mollisols (Argixerolls), Alfisols (Haploxeralfs)	Bluesprin, Klickson, Tannahill, Suloaf, Agatha, Keuterrville, McDaniel, Rockly. On canyon slopes: stony soils.	Wheatgrass–bluegrass, western ponderosa pine forest/ Bluebunch wheatgrass, bluegrass, snowberry, Idaho fescue, open Douglas-fir–ponderosa pine forest.	Mostly grass- or brush-covered. Livestock grazing and recreation.

ID	Ecoregion	Physiography	Geology (Surficial and Bedrock)	General Soil Order (Great Order)	Common Soil Series	Potential and Present Vegetation	Dominant Land Use and Land Cover
11i	Continental Zone Foothills	Unglaciated. Foothills.	Quaternary colluvium. Mostly Tertiary basalt. Also some Jurassic graywackes and granitics.	Mollisols (Argixerolls), Aridisols (Haplargids), Vertisols (Haploxererts)	McDaniel, Riggins, Meland, Reywat, Gem, Bakeoven, Glasgow, Agerdelly, Rockly	Mostly wheatgrass–bluegrass, sagebrush steppe/ Idaho fescue, bluebunch wheatgrass, bluegrass, sagebrush, snowberry, mountain mahogany; scattered Douglas-fir, ponderosa pine.	Shrub- and grass-covered. Rangeland and wildlife habitat.
12a	Treasure Valley	Unglaciated. Valley with many canals and reservoirs.	Quaternary alluvium, loess, lacustrine, alluvial fan deposits, basalt and sedimentary rock. Tertiary sedimentary rock.	Aridisols (Haplocalcids, Calciargids, Argidurids, Haplocambids, Haplodurids), Mollisols (Argixerolls, Haplaquolls, Haploxerolls)	Power, Elijah, Haw, Moulton, Baldock, Greenleaf, Owyhee, Purdam, Harpt, Scism, Minidoka, Bram	Sagebrush steppe/ Wyoming–basin big sagebrush, bluegrass, bluebunch wheatgrass, cheatgrass, basin wildrye, Thurber needlegrass, rabbitbrush. Saline areas: shadscale, greasewood, saltgrass.	Irrigated cropland, pastureland, suburban and urban developments, and industrial areas. Wheat, barley, sugar beets, potatoes, beans, and specialty crops are grown. Elsewhere: grazing. Land use has affected water quality.
12f	Semiarid Foothills	Unglaciated. Foothills, alluvial fans, hills, and intervening valleys. A few perennial streams occur.	Quaternary alluvium, colluvium, loess, sedimentary rocks, and extrusive rocks. Tertiary basalt flows, rhyolite tuffs, quartz latite lavas, and sedimentary rocks and Cretaceous granitics.	Mollisols (Argixerolls, Haploxerolls, Durixerolls), Aridisols (Haplargids)	Gem, Gwin, Newell, Mehlhorn, Gaib, Elkcreek, Bakeoven, Reywat, Glasgow, Brownlee, Riggins, Shoepeg, Appledellia. Shallow, clayey soils with a high shrink swell potential are common.	Sagebrush steppe/ Cheatgrass, medusahead wildrye, bluebunch wheatgrass, bluegrass, Idaho fescue, big sagebrush, bitterbrush. Wetter areas: bunch grasses, sedges, rushes, clovers.	Shrub- and grass-covered; wildfire frequency is high. Rangeland and wildlife habitat with some irrigated alfalfa farming in valleys.
12g	Eastern Snake River Basalt Plains	Unglaciated. Irregular plain.	Quaternary loess, alluvium, basalt flows, and cinder cones. Rock outcrops occur.	Aridisols (Haplocalcids, Haplodurids, Haplocambids, Haplargids), Mollisols (Argixerolls, Haploxerolls, Calcixerolls), Entisols (Xeropsamments)	Pancheri, McCarey, Portneuf, Minidoka, Jipper, Juniperbute, Grassyridge, Scoon, Trevino, Portino, Whiteknob, Malm, Eaglecone. Shallow, stony soils occur.	Sagebrush steppe/ Bluebunch wheatgrass, basin and Wyoming big sagebrush, Thurber needlegrass, Indian ricegrass, bitterbrush, bluegrass, cheatgrass. Saline areas: fourwing saltbush, shadscale, winterfat.	Shrub- and grass-covered. Mostly rangeland. Small, sprinkler-irrigated areas of deep soil occur and are used for pasture or small grain, potato, sugar beet, bean, and alfalfa farming.

ID	Ecoregion	Physiography	Geology (Surficial and Bedrock)	General Soil Order (Great Order)	Common Soil Series	Potential and Present Vegetation	Dominant Land Use and Land Cover
12h	Mountain Home Uplands	Unglaciated. Plains with hills and basalt-capped buttes.	Quaternary alluvium, loess. Lacustrine deposits, basalt flows, sedimentary rocks. Tertiary basalt.	Aridisols (Calciargids, Haplargids, Durargids, Argidurids, Paleargids, Haplocambids, Haplodurids)	Power, Tenmile, Colthorp, Gooding, Chilcott, Kunaton, Royal, Truesdale, Timmerman	Mostly sagebrush steppe; some saltbush–greasewood in SW/ Cheatgrass, crested wheatgrass, medusahead wildrye, Wyoming and basin big sagebrush, alkali sagebrush, antelope bitterbrush. Native plant regeneration limited by low available moisture.	Shrub- and grass-covered. Primarily livestock grazing and wildlife habitat. Stock carrying capacity is low. Some areas at lower elevations are irrigated for pasture and hay.
12i	Magic Valley	Unglaciated. Valley with many canals and reservoirs.	Quaternary alluvium, loess, and basalt. Tertiary basalt and Tertiary quartz latite.	Aridisols (Haplocalcids, Haplocambids, Calciargids, Paleargids), Entisols (Torriorthents), Mollisols (Durixerolls)	Portneuf, Trevino, Paulville, Tindahay, Weeks, Buko, Gooding, Fathom, Minveno, Power, Purdam	Mostly sagebrush steppe. Lower terraces: saltbush-greasewood/ Wyoming and basin big sagebrush, alkali sagebrush, bluebunch wheatgrass, Thurber needlegrass, squirreltail, bluegrass, needleandthread, Indian ricegrass, fourwing saltbush.	Irrigated wheat, barley, alfalfa, potatoes, sugar beets, beans, and pastureland. Dairy and livestock farms, rangeland, and residential, commercial, and industrial developments also occur. Land use has affected water quality.
12j	Unwooded Alkaline Foothills	Unglaciated. Rolling foothills, hills, benches, alluvial fans, and scattered badlands. Perennial streams are rare.	Quaternary sandy, alkaline lacustrine sediments are characteristic and alluvium also occurs. Quaternary sedimentary rocks and Tertiary basalt.	Aridisols (Argidurids, Calciargids, Haplocalcids, Durargids), Mollisols (Haploxerolls, Argixerolls), Entisols (Torripsamments, Torriorthents)	Chilcott, Haw, Power, Lolalita, Payette, Quincy, Cashmere, Mazuma, Shoofly, Bram	Saltbush–greasewood; sagebrush steppe/ Wyoming big sagebrush, bluebunch wheatgrass, crested wheatgrass, cheatgrass, bluegrass, Thurber needlegrass, and Indian ricegrass. In saline-alkaline areas: Bailey's greasewood, black greasewood, bud sagebrush, shadscale, inland saltgrass, and seepweed.	Shrub- and grass-covered. Mostly rangeland and wildlife habitat. Some irrigated hayland, pastureland, and cropland growing alfalfa, sugar beets, and small grains at lower elevations near reservoirs and the Snake River.

ID	Ecoregion	Physiography	Geology (Surficial and Bedrock)	General Soil Order (Great Order)	Common Soil Series	Potential and Present Vegetation	Dominant Land Use and Land Cover
16f	Foothill Shrublands-Grasslands	Unglaciated. Foothills, hills, benches, and ridges.	Quaternary alluvium and colluvium. Cretaceous granitics, Paleozoic sandstone, Tertiary basalt, tuffs, quartz monzodiorite, and sedimentary rocks.	Mollisols (Haploxerolls, Argixerolls, Argicryolls, Haplocryolls), Inceptisols (Eutrocryepts)	Roanhide, Rainey, Vitale, Elksel, Moonstone, Mulshoe, Povey, Friedman, Starhope, Ketchum, Dollarhide	Sagebrush steppe/ Bluebunch wheatgrass, mountain and Wyoming big sagebrush, Thurber needlegrass, bluegrass, Idaho fescue, bitterbrush, snowberry.	Grass- and brush-covered. Mostly rangeland, wildlife habitat, and expanding rural residential development.
16j	Hot Dry Canyons	Unglaciated. Deep, precipitous canyons.	Pleistocene glacial drift, alluvium, and colluvium. Tertiary intrusives and rhyolite, Cretaceous granitics, Jurassic granitics, Permian schist, and Precambrian quartzite, gneiss, and schist. Rock outcrops occur.	Mollisols (Argixerolls)	Howcan, Klickson, Bluesprin, Tannahill, Suloaf.	Western ponderosa pine forest/ South-facing slopes: mountain big sagebrush, bluebunch wheatgrass, Idaho fescue, ponderosa pine. North-facing slopes: Douglas-fir, ponderosa pine.	Forest-, brush-, and grass-covered. Logging, livestock grazing, wildlife habitat, mining, transportation, and recreation.
16k	Southern Forested Mountains	Partly glaciated. Mountains.	Quaternary glacial deposits and alluvium. Mostly Cretaceous igneous rocks. Also, Tertiary basalt and Precambrian quartzite, phyllite, and undifferentiated metamorphics.	Mollisols (Haplocryolls), Entisols (Cryopsamments), Inceptisols (Eutrocryepts, Dystrocryepts). Often andic.	Pyle, Jugson, Bryan, Broad Canyon, Bluebell, Ticanot. Droughty, highly erodible soils of low fertility have developed from granitic rocks.	Grand fir–Douglas-fir forest, western ponderosa pine forest/ Douglas-fir, grand fir, western larch (in north), white fir, subalpine fir. In canyons: ponderosa pine, mountain mahogany, Idaho fescue, and bluebunch wheatgrass.	Forested. Timber, mining, recreation, livestock grazing, and wildlife habitat. Streams subject to sediment loading when soils are disturbed.
80a	Dissected High Lava Plateau	Unglaciated. Alluvial fans, rolling plains, hills, and shear-walled canyons cut into extrusive rocks. Externally-drained.	Quaternary alluvium, colluvium, and loess. Tertiary rhyolite, basalt, and tuffaceous rocks.	Aridisols (Argidurids, Haplodurids, Haplargids, Haplocalcids, Durargids), Mollisols (Haploxerolls)	Purdam, Colthorp, Raftriver, Xerxes, Aysees, Bruncan, Heckison, Roseworth, Arbidge	Sagebrush steppe/ Wyoming big sagebrush, Thurber needlegrass, bluebunch wheatgrass, bluegrass, western wheatgrass, cheatgrass. Rocky uplands: Utah juniper.	Brush- and grass-covered. Mostly rangeland and wildlife habitat. Some pastureland and cropland primarily producing hay and small grains.

ID	Ecoregion	Physiography	Geology (Surficial and Bedrock)	General Soil Order (Great Order)	Common Soil Series	Potential and Present Vegetation	Dominant Land Use and Land Cover
80f	Owyhee Uplands and Canyons	Unglaciated. Deep, precipitous river canyons, lava fields, badlands, and tuffaceous outcrops that are riddled by caves.	Quaternary colluvium and alluvium. Tertiary rhyolite, tuffaceous rocks, basalt flows, and sedimentary rock and Cretaceous granitic intrusions.	Alfisols (Durixeralfs, Haploxeralfs), Aridisols (Petroargids, Calcids), Mollisols (Argixerolls)	Gariper, Snell, Fairylawn, Willhill, Hat, Kanlee, Wickahoney	Mostly sagebrush steppe/ Wyoming big sagebrush, bluebunch wheatgrass, low sagebrush, Idaho fescue, bluegrass, squirreltail, bitterbrush, western juniper.	Mostly brush- and grass-covered. Mostly rangeland and wildlife habitat. Some hay and small grain farming.

Appendix Table 2 – Average monthly maximum, minimum, and average temperatures (°F) along with growing degree-days (F° units) and precipitation (inches) for selected stations within the Snake River Valley AVA for the 1981-2010 Climate Normals. (Data Source: NOAA, 2011, NA = not available)

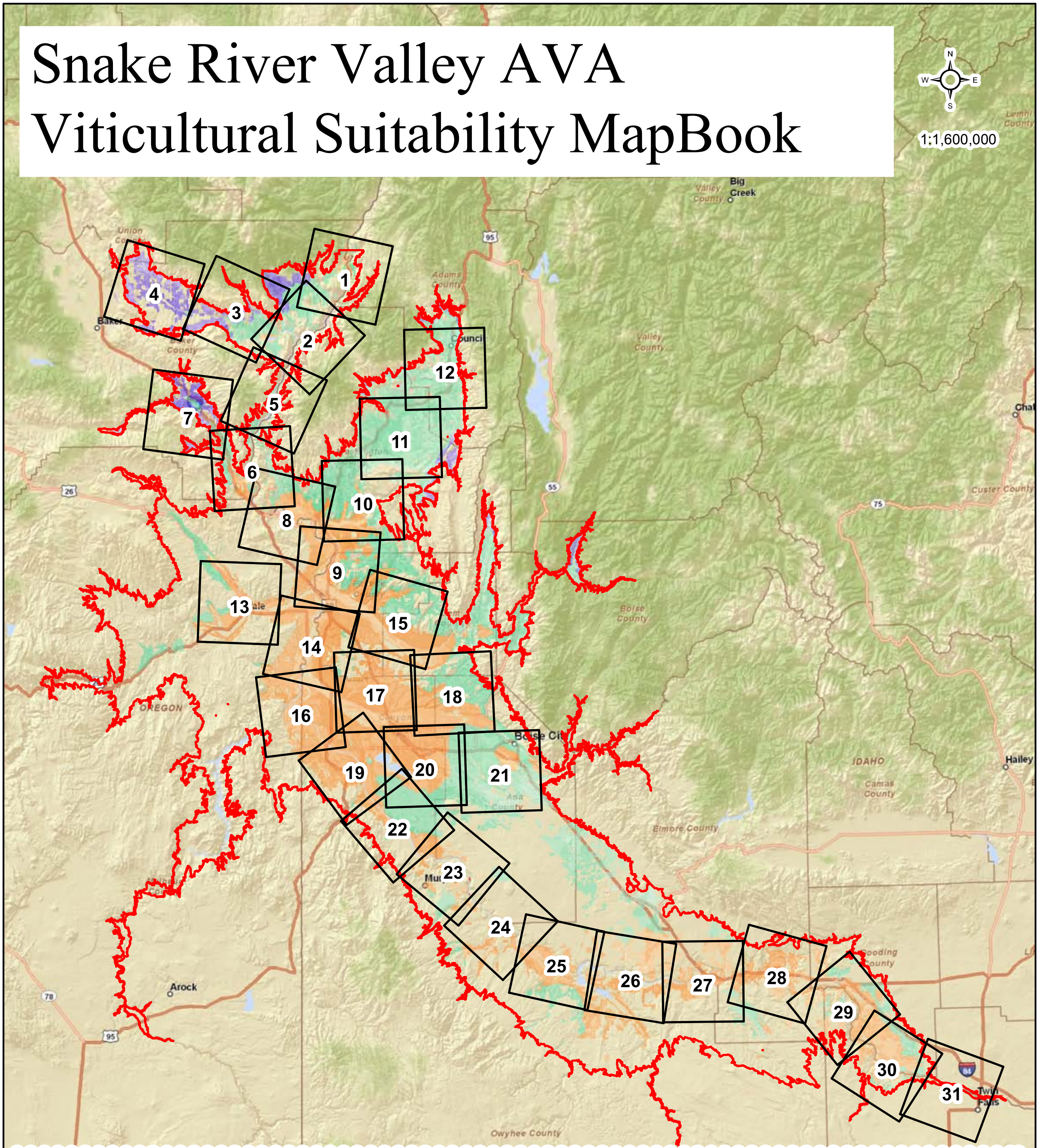
Station	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
	Tmax (°F)	37.8	44.7	54.6	62.3	71.6	81.3	91.2	89.7	78.8	64.8	48.2	37.5	63.6
	Tmin (°F)	24.7	28.3	34.4	39.3	46.5	53.7	60.4	59.6	51.0	40.9	31.9	24.0	41.3
BOISE AIR TERMINAL, ID	Tavg (°F)	31.3	36.5	44.5	50.8	59.1	67.5	75.8	74.7	64.9	52.8	40.0	30.7	52.5
	GDD (F°)	0	0	0	24	282	525	800	766	447	87	0	0	2930
	Precip (in)	1.24	0.99	1.39	1.23	1.39	0.69	0.33	0.24	0.58	0.75	1.35	1.55	11.73
	Tmax (°F)	42.5	49.7	60.3	68.3	76.6	85.5	94.8	94.0	83.4	69.8	53.0	41.8	68.4
	Tmin (°F)	26.0	28.6	34.5	39.5	46.9	53.9	59.6	57.4	48.2	39.1	31.6	25.0	40.9
BRUNEAU, ID	Tavg (°F)	34.2	39.2	47.4	53.9	61.8	69.7	77.2	75.7	65.8	54.4	42.3	33.4	54.7
	GDD (F°)	0	0	0	117	366	591	843	797	474	136	0	0	3324
	Precip (in)	0.85	0.56	0.82	0.76	0.98	0.57	0.14	0.17	0.36	0.56	0.93	0.92	7.62
	Tmax (°F)	36.0	41.2	51.9	60.2	68.7	77.6	87.5	86.6	76.3	62.8	46.8	36.4	61.1
	Tmin (°F)	20.4	23.2	30.3	35.8	43.6	50.8	57.8	55.9	46.8	37.1	27.5	20.1	37.5
BUHL #2, ID	Tavg (°F)	28.2	32.2	41.1	48.0	56.2	64.2	72.7	71.3	61.6	49.9	37.1	28.2	49.3
	GDD (F°)	0	0	0	0	192	426	704	660	348	0	0	0	2330
	Precip (in)	0.95	0.75	1.07	1.01	1.18	0.84	0.27	0.31	0.38	0.84	1.23	1.21	10.04
	Tmax (°F)	38.8	46.8	58.6	66.5	75.7	84.6	93.7	92.9	82.0	67.4	50.2	38.5	66.4
	Tmin (°F)	22.9	26.2	32.9	38.0	46.2	53.1	59.9	57.0	46.8	37.3	29.3	22.3	39.4
CALDWELL, ID	Tavg (°F)	30.8	36.5	45.7	52.2	61.0	68.8	76.8	74.9	64.4	52.3	39.7	30.4	52.9
	GDD (F°)	0	0	0	66	341	564	831	772	432	71	0	0	3077
	Precip (in)	1.41	0.95	1.29	1.07	1.20	0.64	0.26	0.28	0.51	0.71	1.18	1.60	11.10
	Tmax (°F)	30.9	37.5	52.0	63.4	72.8	81.7	92.8	91.8	80.9	64.8	45.4	32.4	62.3
	Tmin (°F)	15.8	18.6	28.9	35.5	42.3	49.3	55.4	53.2	43.5	34.0	26.4	17.4	35.1
CAMBRIDGE, ID	Tavg (°F)	23.3	28.0	40.4	49.4	57.6	65.5	74.1	72.5	62.2	49.4	35.9	24.9	48.7
	GDD (F°)	0	0	0	0	236	465	747	698	366	0	0	0	2511
	Precip (in)	2.89	2.34	2.10	1.43	1.70	1.19	0.39	0.42	0.70	1.28	2.73	3.81	20.98
	Tmax (°F)	34.4	39.0	51.0	61.6	71.2	80.0	90.0	90.2	79.8	65.0	46.9	34.3	62.1
	Tmin (°F)	17.4	19.2	28.5	34.6	42.3	49.3	55.7	54.8	45.6	34.3	25.2	17.2	35.4
COUNCIL, ID	Tavg (°F)	25.9	29.1	39.8	48.1	56.8	64.7	72.9	72.5	62.7	49.7	36.1	25.8	48.7
	GDD (F°)	0	0	0	0	211	441	710	698	381	0	0	0	2440
	Precip (in)	2.51	2.30	2.27	1.83	2.02	1.54	0.53	0.56	0.84	1.47	3.10	2.74	21.71
	Tmax (°F)	39.4	46.6	58.0	65.2	73.1	81.0	89.3	88.7	79.4	66.9	50.4	39.2	64.9
	Tmin (°F)	24.6	27.6	34.7	39.8	47.2	53.6	59.4	57.5	49.2	39.8	31.5	23.8	40.8
DEER FLAT DAM, ID	Tavg (°F)	32.0	37.1	46.3	52.5	60.1	67.3	74.4	73.1	64.3	53.3	40.9	31.5	52.8
	GDD (F°)	0	0	0	75	313	519	756	716	429	102	0	0	2911
	Precip (in)	1.06	0.87	1.24	1.00	1.13	0.72	0.29	0.25	0.45	0.64	1.03	1.29	9.97
	Tmax (°F)	37.5	44.7	55.2	62.8	71.8	80.8	90.3	89.2	78.6	65.4	48.6	37.7	63.7
	Tmin (°F)	22.4	25.7	31.7	36.3	43.5	50.6	56.9	55.7	47.1	37.8	29.2	22.4	38.3
EMMETT 2 E, ID	Tavg (°F)	29.9	35.2	43.5	49.6	57.7	65.7	73.6	72.4	62.9	51.6	38.9	30.1	51.0
	GDD (F°)	0	0	0	0	239	471	732	694	387	50	0	0	2572
	Precip (in)	1.66	1.40	1.55	1.26	1.40	0.83	0.31	0.30	0.51	0.86	1.65	2.08	13.81

Station	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
GARDEN VALLEY, ID	Tmax (°F)	35.0	42.4	52.9	62.3	70.9	79.6	89.7	89.7	79.7	65.0	45.0	34.1	62.3
	Tmin (°F)	18.2	20.4	26.8	31.8	37.8	43.6	47.4	44.8	37.6	30.4	25.5	17.9	31.9
	Tavg (°F)	26.6	31.4	39.9	47.0	54.4	61.6	68.5	67.3	58.7	47.7	35.3	26.0	47.1
	GDD (F°)	0	0	0	0	136	348	574	536	261	0	0	0	1855
	Precip (in)	3.69	2.48	2.68	2.10	1.89	1.39	0.58	0.51	0.97	1.71	3.70	4.82	26.52
GLENNS FERRY, ID	Tmax (°F)	41.1	47.7	58.5	66.9	76.1	86.4	96.9	95.2	83.7	70.0	52.5	40.2	68.0
	Tmin (°F)	21.7	23.9	29.7	34.7	42.5	49.9	55.4	52.6	42.6	33.8	26.9	21.4	36.3
	Tavg (°F)	31.4	35.8	44.1	50.8	59.3	68.2	76.2	73.9	63.2	51.9	39.7	30.8	52.2
	GDD (F°)	0	0	0	24	288	546	812	741	396	59	0	0	2866
	Precip (in)	1.28	0.89	1.11	0.87	1.02	0.72	0.26	0.27	0.45	0.88	1.16	1.55	10.46
GRAND VIEW 4 NW, ID	Tmax (°F)	39.5	47.4	58.7	66.4	75.3	83.6	92.1	91.0	80.4	67.0	50.1	38.5	65.9
	Tmin (°F)	23.0	25.8	31.9	37.3	45.5	52.3	57.7	55.0	45.6	36.3	28.5	21.4	38.4
	Tavg (°F)	31.3	36.6	45.3	51.9	60.4	68.0	74.9	73.0	63.0	51.7	39.3	29.9	52.2
	GDD (F°)	0	0	0	57	322	540	772	713	390	53	0	0	2847
	Precip (in)	0.68	0.55	0.80	0.63	0.94	0.68	0.21	0.21	0.40	0.48	0.79	0.78	7.15
HAGERMAN 2 SW, ID	Tmax (°F)	39.0	45.5	56.4	64.7	74.0	83.0	92.4	91.2	81.1	67.7	50.4	38.7	65.4
	Tmin (°F)	21.3	23.8	30.5	35.5	43.3	50.0	54.8	52.1	43.0	34.2	27.2	20.9	36.5
	Tavg (°F)	30.1	34.7	43.4	50.1	58.7	66.5	73.6	71.6	62.0	51.0	38.8	29.8	51.0
	GDD (F°)	0	0	0	3	270	495	732	670	360	31	0	0	2560
	Precip (in)	1.21	1.06	0.96	0.80	0.93	0.66	0.19	0.30	0.40	0.71	1.27	1.69	10.18
HALFWAY, OR	Tmax (°F)	33.5	39.7	52.4	63.0	71.7	79.8	89.6	88.9	79.2	64.6	46.3	34.1	62.0
	Tmin (°F)	16.2	18.1	27.2	31.7	37.9	43.7	48.5	46.4	38.6	30.4	24.8	16.7	31.8
	Tavg (°F)	24.8	28.9	39.8	47.4	54.8	61.8	69.0	67.7	58.9	47.5	35.5	25.4	46.9
	GDD (F°)	0	0	0	0	149	354	589	549	267	0	0	0	1908
	Precip (in)	3.41	2.25	1.83	1.63	1.81	1.37	0.54	0.56	0.72	1.21	2.96	3.58	21.87
HOMEDALE 1 SE, ID	Tmax (°F)	39.1	45.9	57.7	65.6	74.5	83.2	93.2	92.6	82.1	67.6	51.0	38.4	66.0
	Tmin (°F)	20.2	21.6	28.6	34.7	42.9	49.7	55.4	51.7	42.2	33.3	26.3	19.2	35.6
	Tavg (°F)	29.7	33.8	43.2	50.2	58.7	66.5	74.3	72.2	62.2	50.4	38.7	28.8	50.8
	GDD (F°)	0	0	0	6	270	495	753	688	366	12	0	0	2591
	Precip (in)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HUNTINGTON, OR	Tmax (°F)	36.6	43.7	55.5	64.0	73.4	82.4	93.1	92.4	81.6	66.7	48.5	36.8	64.7
	Tmin (°F)	20.2	23.9	32.1	38.5	47.3	55.2	63.5	60.8	49.9	37.1	27.3	20.1	39.7
	Tavg (°F)	28.4	33.8	43.8	51.3	60.3	68.8	78.3	76.6	65.7	51.9	37.9	28.5	52.2
	GDD (F°)	0	0	0	39	319	564	877	825	471	59	0	0	3154
	Precip (in)	1.71	1.33	1.23	0.99	1.34	0.93	0.52	0.43	0.42	0.92	1.77	2.45	14.04
IRONSIDE 2 W, OR	Tmax (°F)	34.2	39.0	49.8	58.3	66.9	75.3	86.4	86.0	76.2	63.1	44.5	33.8	59.6
	Tmin (°F)	14.3	18.1	25.7	31.9	38.3	44.8	52.6	51.4	42.6	32.1	23.2	14.5	32.5
	Tavg (°F)	24.3	28.6	37.7	45.1	52.6	60.1	69.5	68.7	59.4	47.6	33.8	24.2	46.1
	GDD (F°)	0	0	0	0	81	303	605	580	282	0	0	0	1850
	Precip (in)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

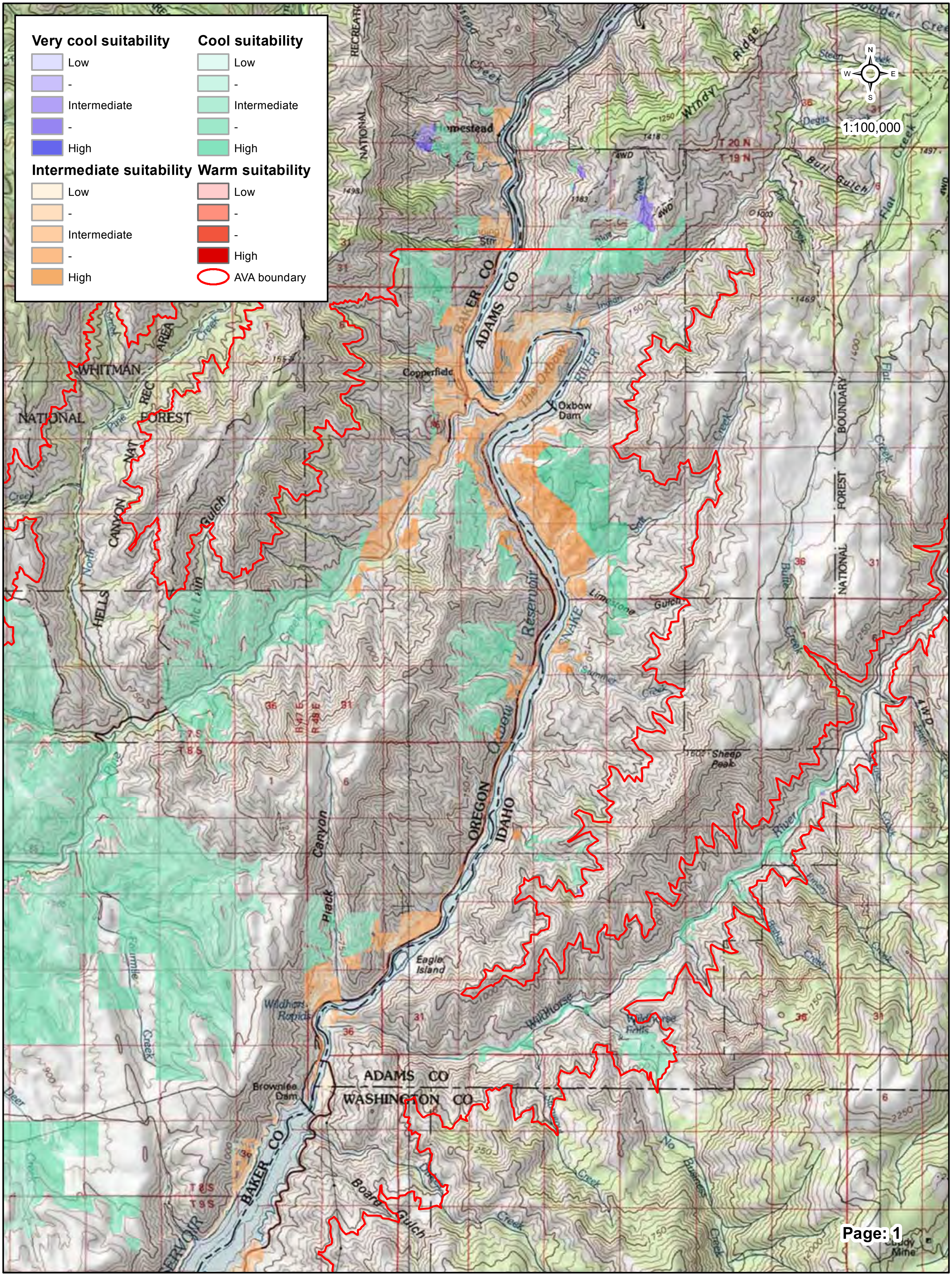
Station	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
KUNA, ID	Tmax (°F)	38.3	46.3	57.9	65.6	73.2	83.4	91.8	89.5	79.9	66.8	49.3	38.0	65.1
	Tmin (°F)	23.7	26.6	33.3	36.5	43.7	51.3	56.6	52.9	45.6	36.3	30.0	22.6	38.3
	Tavg (°F)	31.0	36.5	45.6	51.1	58.5	67.4	74.2	71.2	62.8	51.6	39.6	30.3	51.7
	GDD (F°)	0	0	0	33	264	522	750	657	384	50	0	0	2660
	Precip (in)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MALHEUR EXPERIMENTAL STATION, OR	Tmax (°F)	35.4	43.0	55.6	64.3	73.2	81.6	91.3	90.4	80.1	65.8	48.0	36.3	63.9
	Tmin (°F)	20.5	24.3	31.6	37.1	45.4	52.2	58.2	55.5	46.0	35.9	27.9	20.7	38.0
	Tavg (°F)	28.0	33.7	43.6	50.7	59.3	66.9	74.7	72.9	63.0	50.9	38.0	28.5	50.9
	GDD (F°)	0	0	0	21	288	507	766	710	390	28	0	0	2710
	Precip (in)	1.24	0.93	1.12	0.87	1.15	0.80	0.33	0.31	0.43	0.75	1.16	1.60	10.69
MOUNTAIN HOME, ID	Tmax (°F)	38.7	45.1	55.0	63.0	72.6	83.0	93.4	92.4	80.5	66.3	49.1	38.1	64.9
	Tmin (°F)	22.3	24.8	30.4	35.9	44.0	51.5	58.2	56.4	46.6	36.2	27.9	21.4	38.0
	Tavg (°F)	30.5	35.0	42.7	49.4	58.3	67.2	75.8	74.4	63.5	51.3	38.5	29.7	51.4
	GDD (F°)	0	0	0	0	257	516	800	756	405	40	0	0	2775
	Precip (in)	1.14	0.86	1.20	1.03	1.26	0.59	0.21	0.13	0.50	0.81	1.26	1.56	10.55
NAMPA SUGAR FACTORY, ID	Tmax (°F)	38.7	45.5	56.6	64.6	73.3	82.5	91.9	90.7	79.9	66.4	50.0	39.2	65.0
	Tmin (°F)	22.6	25.7	31.7	36.5	44.1	51.4	57.0	55.1	45.9	36.5	28.7	21.8	38.1
	Tavg (°F)	30.6	35.6	44.1	50.5	58.7	67.0	74.5	72.9	62.9	51.4	39.4	30.5	51.6
	GDD (F°)	0	0	0	15	270	510	760	710	387	43	0	0	2695
	Precip (in)	1.21	0.96	1.26	1.08	1.29	0.68	0.26	0.23	0.48	0.75	1.27	1.47	10.94
ONTARIO KSRV, OR	Tmax (°F)	35.4	43.4	56.4	64.8	74.5	83.6	93.7	91.9	81.2	66.2	48.0	36.0	64.7
	Tmin (°F)	19.6	23.2	30.4	35.9	44.3	52.2	58.4	54.8	44.8	34.3	26.3	19.6	37.1
	Tavg (°F)	27.5	33.3	43.4	50.4	59.4	67.9	76.1	73.3	63.0	50.3	37.1	27.8	50.9
	GDD (F°)	0	0	0	12	291	537	809	722	390	9	0	0	2771
	Precip (in)	1.18	0.80	1.01	0.80	1.28	0.69	0.30	0.18	0.41	0.63	1.10	1.68	10.06
OWYHEE DAM, OR	Tmax (°F)	39.1	45.8	56.6	64.6	73.9	83.3	93.3	92.1	81.3	67.5	50.1	39.2	65.7
	Tmin (°F)	20.4	23.2	29.6	34.6	41.6	48.1	53.4	51.8	44.1	35.1	26.3	19.5	35.7
	Tavg (°F)	29.7	34.5	43.1	49.6	57.8	65.7	73.3	71.9	62.7	51.3	38.2	29.3	50.7
	GDD (F°)	0	0	0	0	242	471	722	679	381	40	0	0	2535
	Precip (in)	0.92	0.76	0.89	0.96	1.16	0.92	0.43	0.38	0.45	0.64	0.92	1.25	9.68
PARMA EXPERMENTAL STATION, ID	Tmax (°F)	36.6	44.2	56.6	64.7	73.1	81.6	91.4	90.8	80.5	66.4	48.9	37.1	64.4
	Tmin (°F)	21.5	25.0	31.5	36.6	45.2	51.5	56.1	53.7	44.9	35.1	27.9	21.0	37.6
	Tavg (°F)	29.1	34.6	44.1	50.7	59.1	66.6	73.8	72.2	62.7	50.8	38.4	29.1	51.0
	GDD (F°)	0	0	0	21	282	498	738	688	381	25	0	0	2633
	Precip (in)	1.18	0.83	1.09	0.93	1.21	0.84	0.30	0.29	0.50	0.71	1.10	1.22	10.20
PAYETTE, ID	Tmax (°F)	36.5	45.0	57.1	64.7	73.2	81.1	90.7	89.0	79.5	66.8	49.7	37.4	64.3
	Tmin (°F)	20.9	24.4	31.9	37.2	45.5	52.5	58.5	56.6	47.7	36.7	28.3	21.3	38.5
	Tavg (°F)	28.7	34.7	44.5	50.9	59.3	66.8	74.6	72.8	63.6	51.7	39.0	29.4	51.4
	GDD (F°)	0	0	0	27	288	504	763	707	408	53	0	0	2749
	Precip (in)	1.35	1.06	1.14	0.82	1.18	0.88	0.28	0.20	0.41	0.67	1.32	1.85	11.16

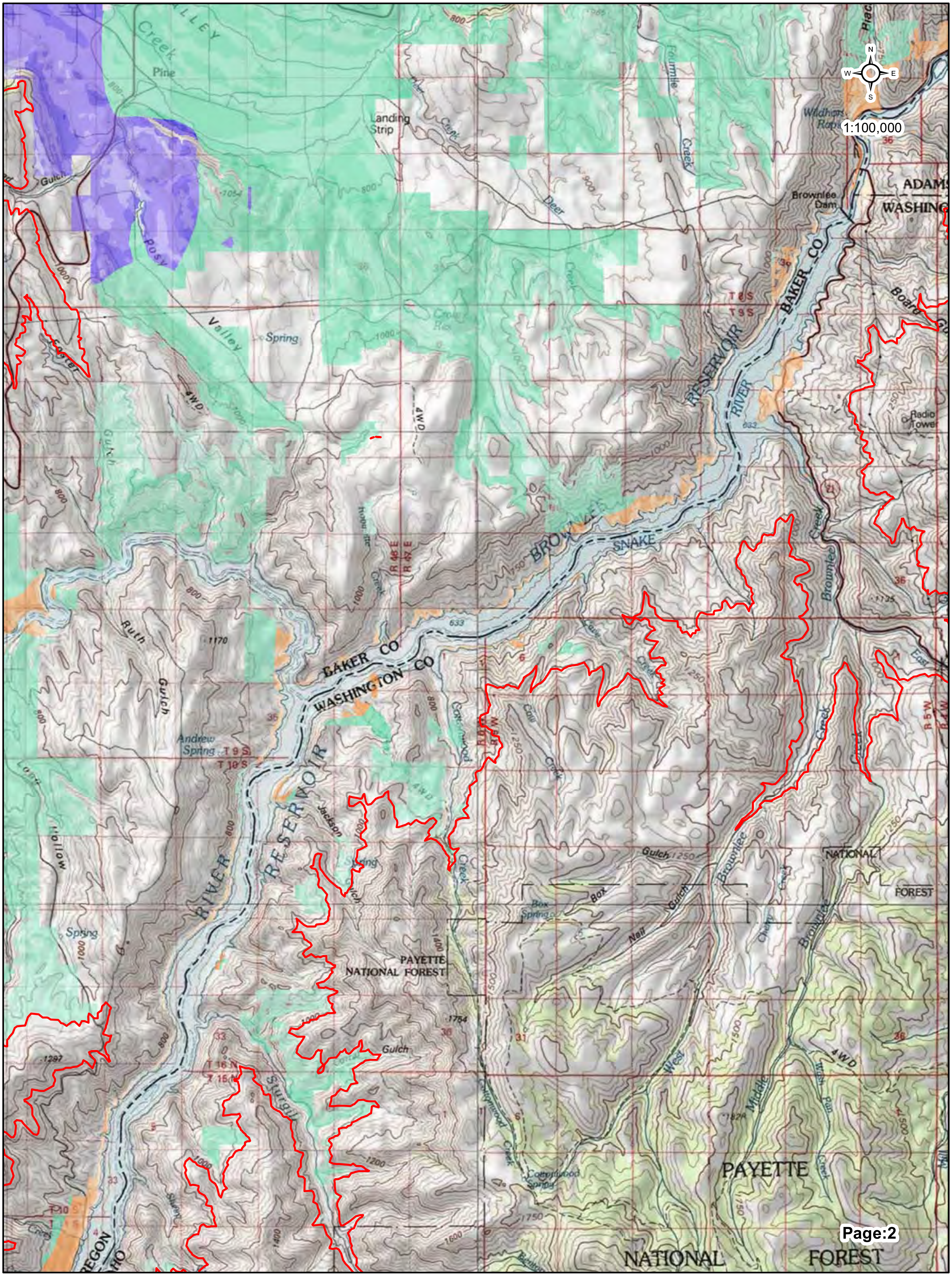
Station	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
RICHLAND, OR	Tmax (°F)	37.5	43.8	54.9	63.8	73.0	81.6	91.5	90.1	80.7	66.2	48.2	38.5	64.2
	Tmin (°F)	20.2	23.2	28.6	33.0	41.0	47.8	53.4	51.1	42.3	32.4	26.0	21.0	35.1
	Tavg (°F)	28.9	33.5	41.7	48.4	57.0	64.7	72.5	70.6	61.5	49.3	37.1	29.8	49.7
	GDD (F°)	0	0	0	0	217	441	698	639	345	0	0	0	2339
	Precip (in)	2.69	0.99	1.06	1.10	1.62	1.19	0.59	0.72	0.57	0.97	1.55	1.95	15.00
SWAN FALLS P H, ID	Tmax (°F)	39.9	47.0	57.6	65.4	74.5	84.0	93.6	92.4	82.0	67.6	50.5	39.6	66.3
	Tmin (°F)	24.5	27.8	35.2	40.7	48.9	56.4	63.4	61.1	51.5	41.2	31.3	24.0	42.2
	Tavg (°F)	32.2	37.4	46.4	53.1	61.7	70.2	78.5	76.7	66.8	54.4	40.9	31.8	54.2
	GDD (F°)	0	0	0	93	363	606	884	828	504	136	0	0	3413
	Precip (in)	0.83	0.58	0.94	0.88	1.17	0.63	0.27	0.19	0.38	0.48	0.89	0.96	8.20
VALE, OR	Tmax (°F)	35.3	43.8	55.8	63.9	73.8	82.5	93.0	90.9	80.0	64.0	46.7	35.7	63.9
	Tmin (°F)	21.5	25.3	32.8	37.4	45.7	52.8	58.9	56.0	46.0	36.1	28.2	20.8	38.5
	Tavg (°F)	28.4	34.6	44.3	50.6	59.8	67.7	75.9	73.5	63.0	50.1	37.4	28.3	51.2
	GDD (F°)	0	0	0	18	304	531	803	729	390	3	0	0	2777
	Precip (in)	1.05	0.82	0.99	0.84	1.17	0.86	0.38	0.27	0.46	0.65	1.07	1.46	10.02
WEISER, ID	Tmax (°F)	35.0	43.4	56.2	64.9	74.3	82.6	92.9	91.0	80.2	65.3	47.7	36.0	64.2
	Tmin (°F)	21.0	24.7	33.2	38.4	46.5	53.3	59.4	56.5	47.1	37.1	29.3	21.8	39.1
	Tavg (°F)	28.0	34.1	44.7	51.6	60.4	68.0	76.1	73.7	63.6	51.2	38.5	28.9	51.7
	GDD (F°)	0	0	0	48	322	540	809	735	408	37	0	0	2899
	Precip (in)	1.74	1.25	1.20	0.95	1.10	1.05	0.31	0.33	0.43	0.73	1.58	1.95	12.62
WESTFALL, OR	Tmax (°F)	36.6	43.3	54.4	63.3	72.1	80.8	90.9	89.6	79.9	65.1	47.0	36.2	63.4
	Tmin (°F)	18.7	22.4	29.4	34.6	42.4	49.8	56.5	54.4	45.1	34.4	24.9	18.1	35.9
	Tavg (°F)	27.7	32.8	41.9	48.9	57.2	65.3	73.7	72.0	62.5	49.8	35.9	27.1	49.7
	GDD (F°)	0	0	0	0	223	459	735	682	375	0	0	0	2474
	Precip (in)	1.14	0.88	0.86	0.87	1.16	0.85	0.49	0.55	0.38	0.63	1.07	1.61	10.49

Snake River Valley AVA Viticultural Suitability MapBook

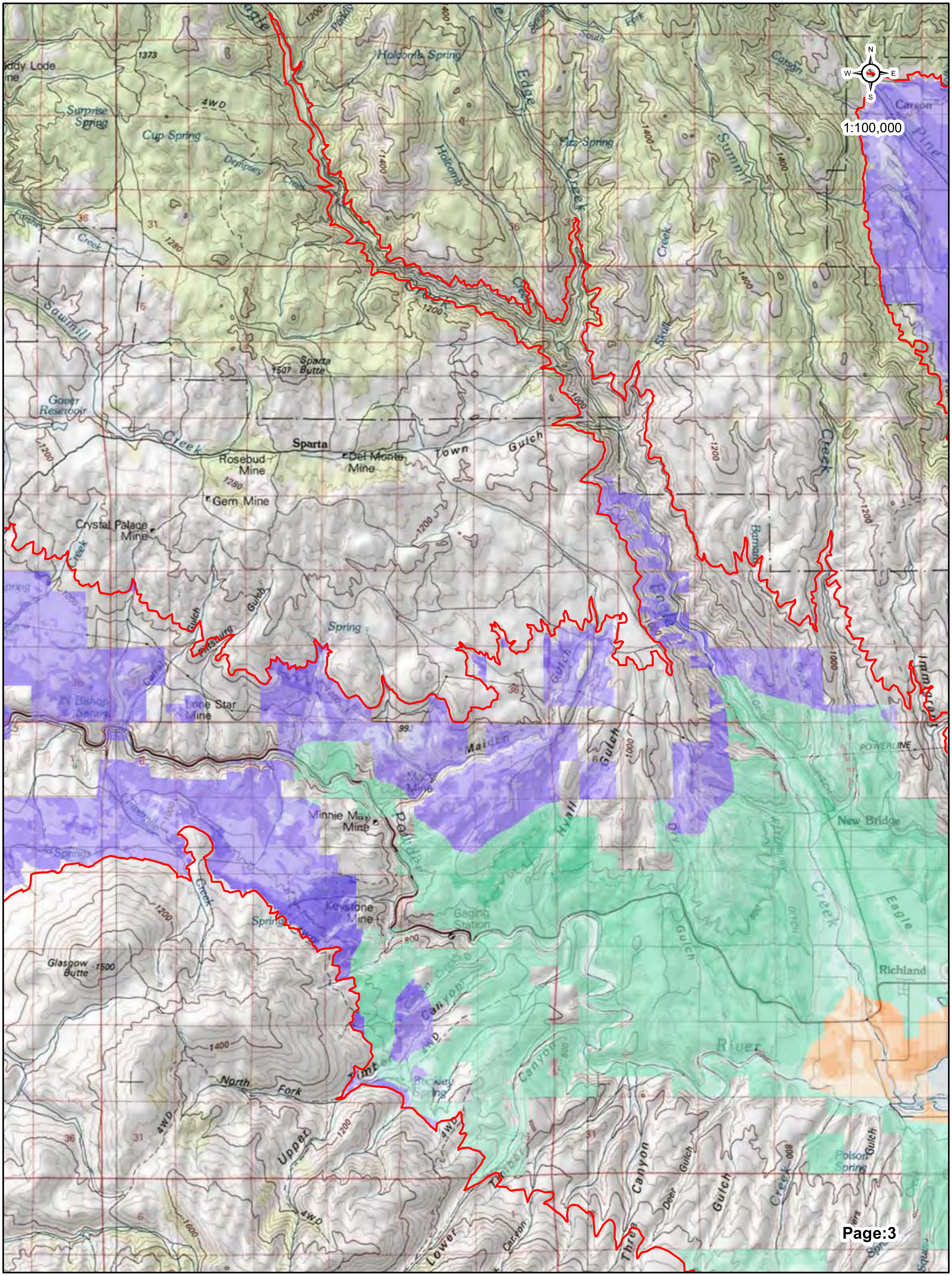


On the following pages is a multi-page indexed mapbook based on the composite suitability shown in Figure 32 which includes the landscape suitability (Figure 29, Table 18) masked by `private lands' that are potentially suitable for agricultural development (Figure 30, Table 19) and classed by growing degree-days regions (Figure 8) for the 1971-2000 Climate Normals in the Snake River Valley AVA. This first page is an irregular index map covering the regions most suitable to viticulture and the subsequent pages follow the index numbers given in each box above. Note that each mapbook page is at the 1:100,000 scale (one centimeter equals one kilometer or one inch equals 1.6 miles) Also note that the first mapbook page has the legend for the entire mapbook showing very cool, cool, intermediate, and warm climate suitability classes with the low to high suitability shading reflecting variations in suitability in topography and soil. The data is displayed on top of USGS topographic quad maps, which might have slight spatial variations in contours or other map features that do not line up perfectly with the terroir zoning data. Finally, any area in the composite suitability that displays a `boxy' structure indicates a land use limitation (some form of governmental or conservation land ownership).

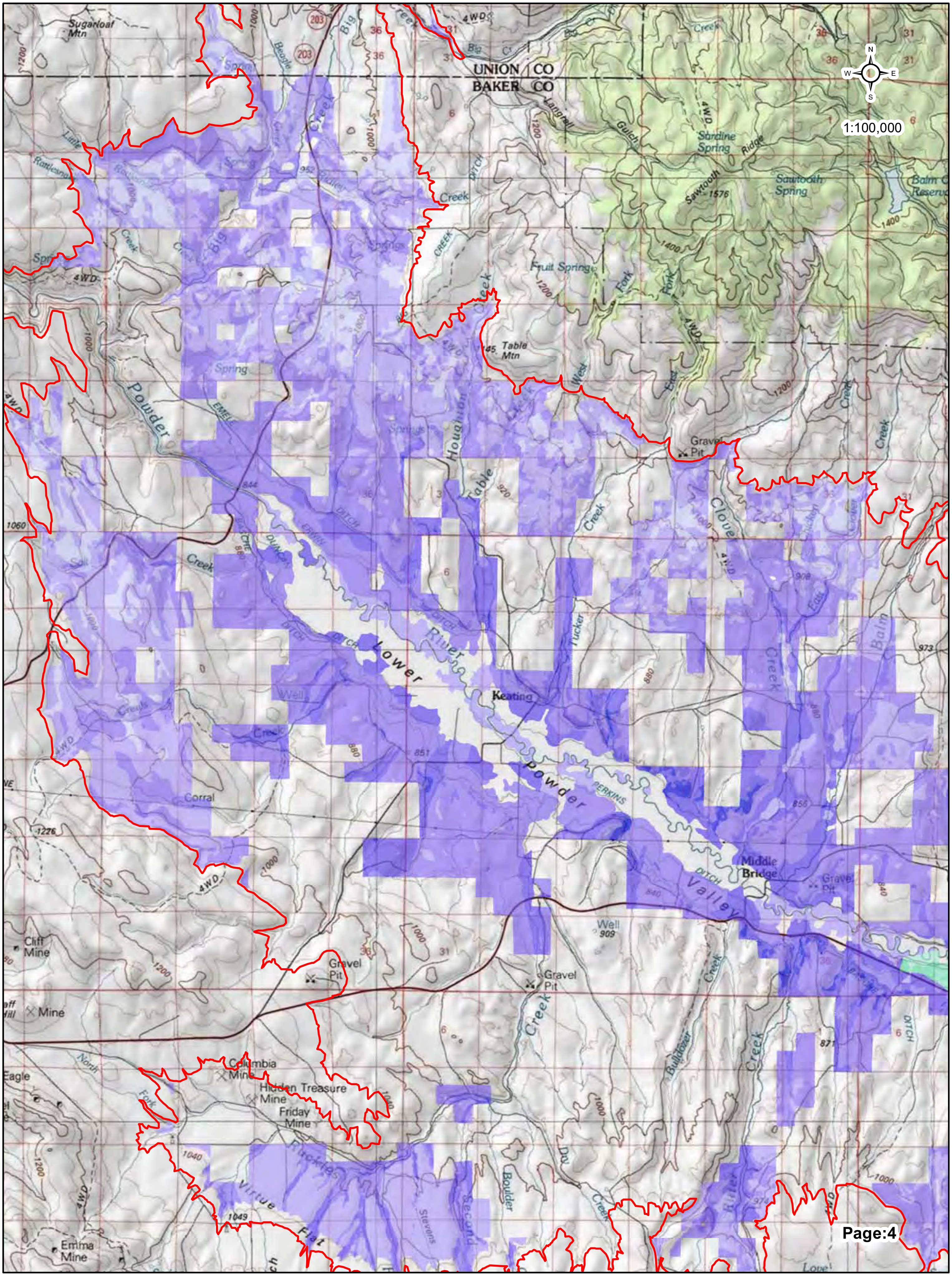

Very cool suitability
Low
-
Intermediate
-
High
Cool suitability
Low
-
Intermediate
-
High
Intermediate suitability
Low
-
Intermediate
-
High
Warm suitability
Low
-
-
High
AVA boundary
1:100,000
Page: 1
BAKER CO
ADAMS CO
OREGON
IDAHO
WASHINGTON CO
Copperfield
Oxbow Dam
Brownlee Dam
Eagle Island
WHITMAN
NATIONAL
FOREST
Sheep Peak
Homestead



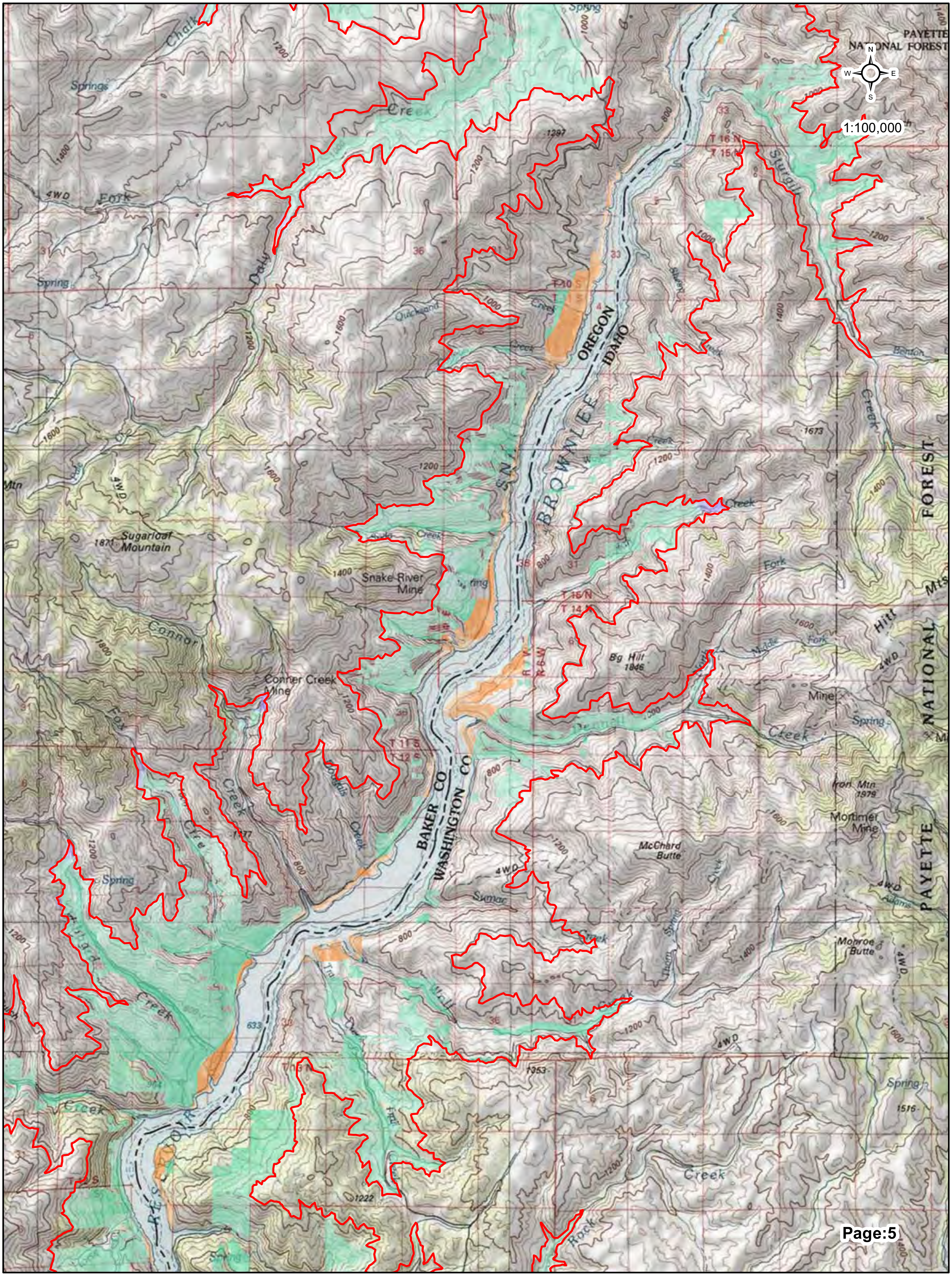
1:100,000
N
S
E
W
Pine
Creek
Landing Strip
Posy
Valley
Spring
Fourmile Creek
Deer
Brownlee Dam
ADAMS
WASHING
T 8 S
T 9 S
BAKER CO
RESERVOIR
RIVER
Radio Tower
BROWNLEE
SNAKE
BAKER CO
WASHINGTON CO
R 46 E
R 47 E
Ruth
Gulch
Andrew Spring
T 9 S
T 10 S
RESERVOIR
RIVER
Jackson
Cottonwood
Creek
Brownlee Creek
Gulch
Box Spring
Box
Neil
Gulch
Cherry Creek
Brownlee
West
Middle
NATIONAL FOREST
PAYETTE NATIONAL FOREST
Sturgill
Cottonwood Spring
PAYETTE
NATIONAL
FOREST
OREGON
IDAHO
4WD
Hollow
Spring

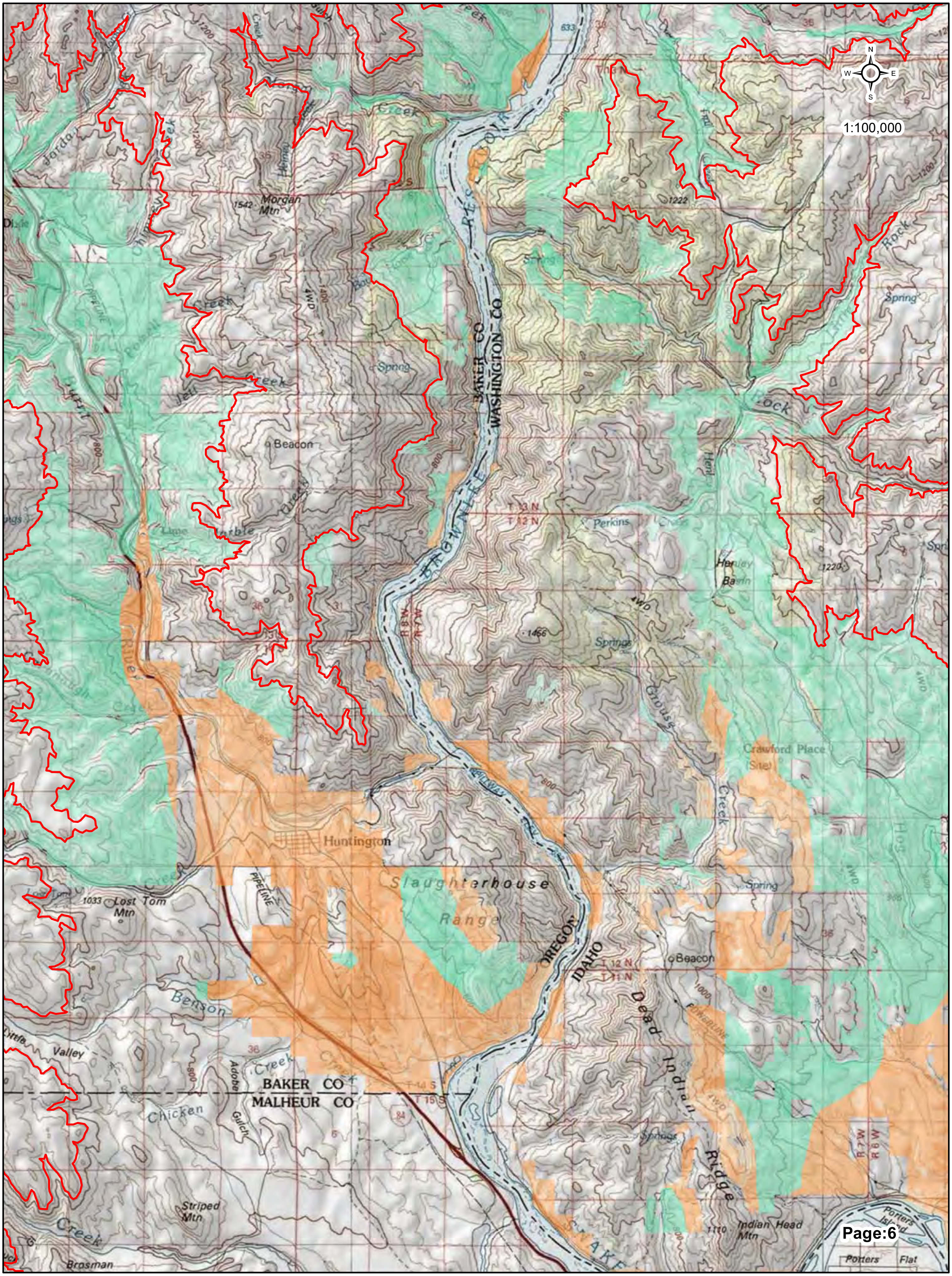


1:100,000
Page:3
Sparta
Rosebud Mine
Del Monte Mine
Gem Mine
Crystal Palace Mine
Lone Star Mine
Macy Mine
Minnie May Mine
Keystone Mine
Gaging Station
New Bridge
Richland
Sparta Butte
Glasgow Butte
Gover Reservoir
Holcomb Spring
Surprise Spring
Cup Spring
Fizz Spring
Poison Spring
Town Gulch
Hyall Gulch
Maiden Gulch
North Fork
Upper
Lower
Three Canyon
Deer Gulch
River
POWERLINE
4WD

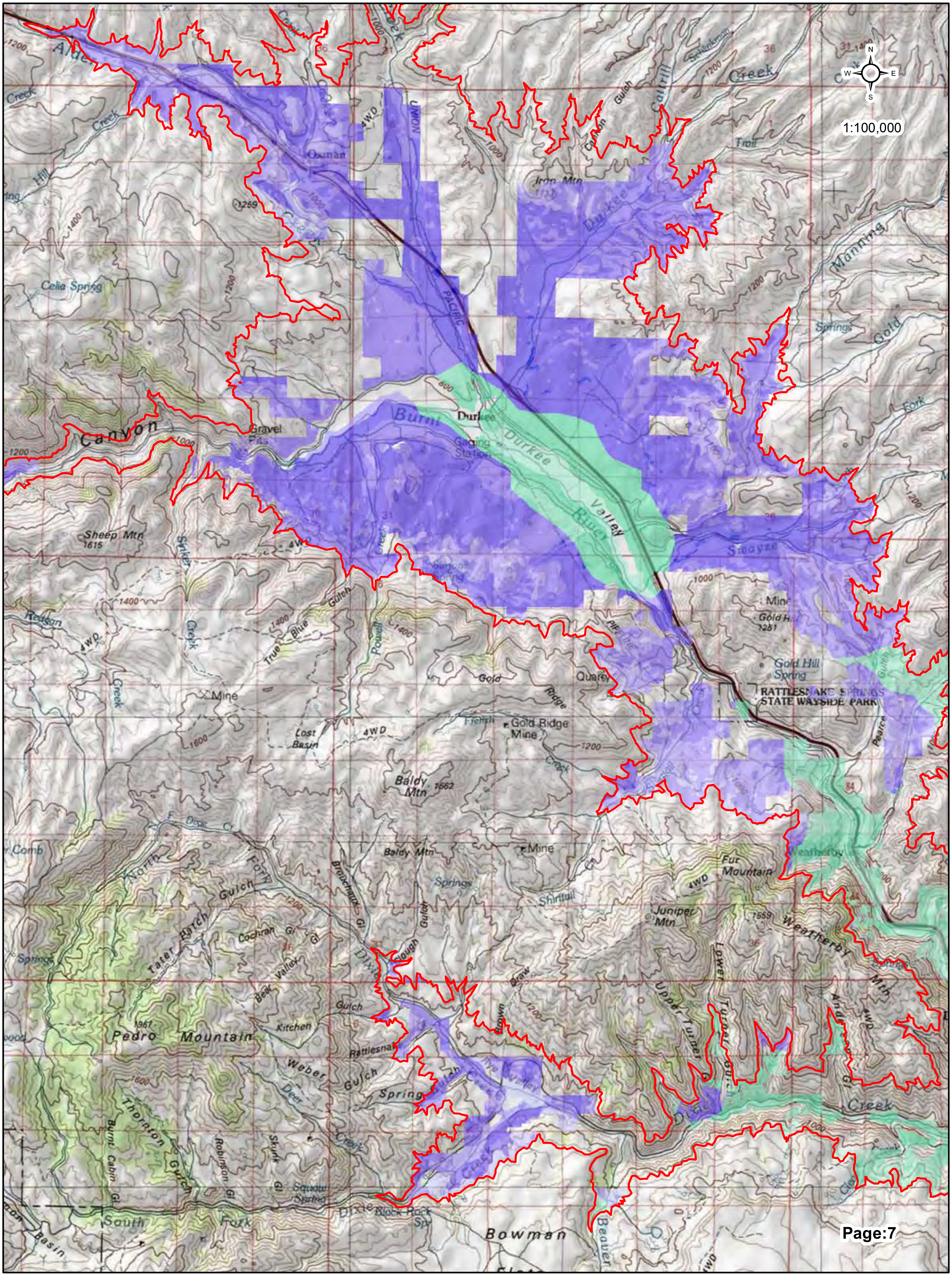


UNION CO
BAKER CO
1:100,000
N
S
E
W
Sugarloaf Mtn
Sardine Spring
Sawtooth Ridge
Sawtooth Spring
Fruit Spring
Table Mtn
Gravel Pit
Powder
Lower Powder River
Keating
Middle Bridge
Valley
Corral
Cliff Mine
Mine
Columbia Mine
Hidden Treasure Mine
Friday Mine
Eagle
Virtue Flat
Emma Mine
Houghton
Tucker
Clover
Balm
Creek
Bulldozer
Boulder
Stevens
Second
EMELE
DUNCAN
PERKINS
DITCH
Well
Spring
4WD
Page:4

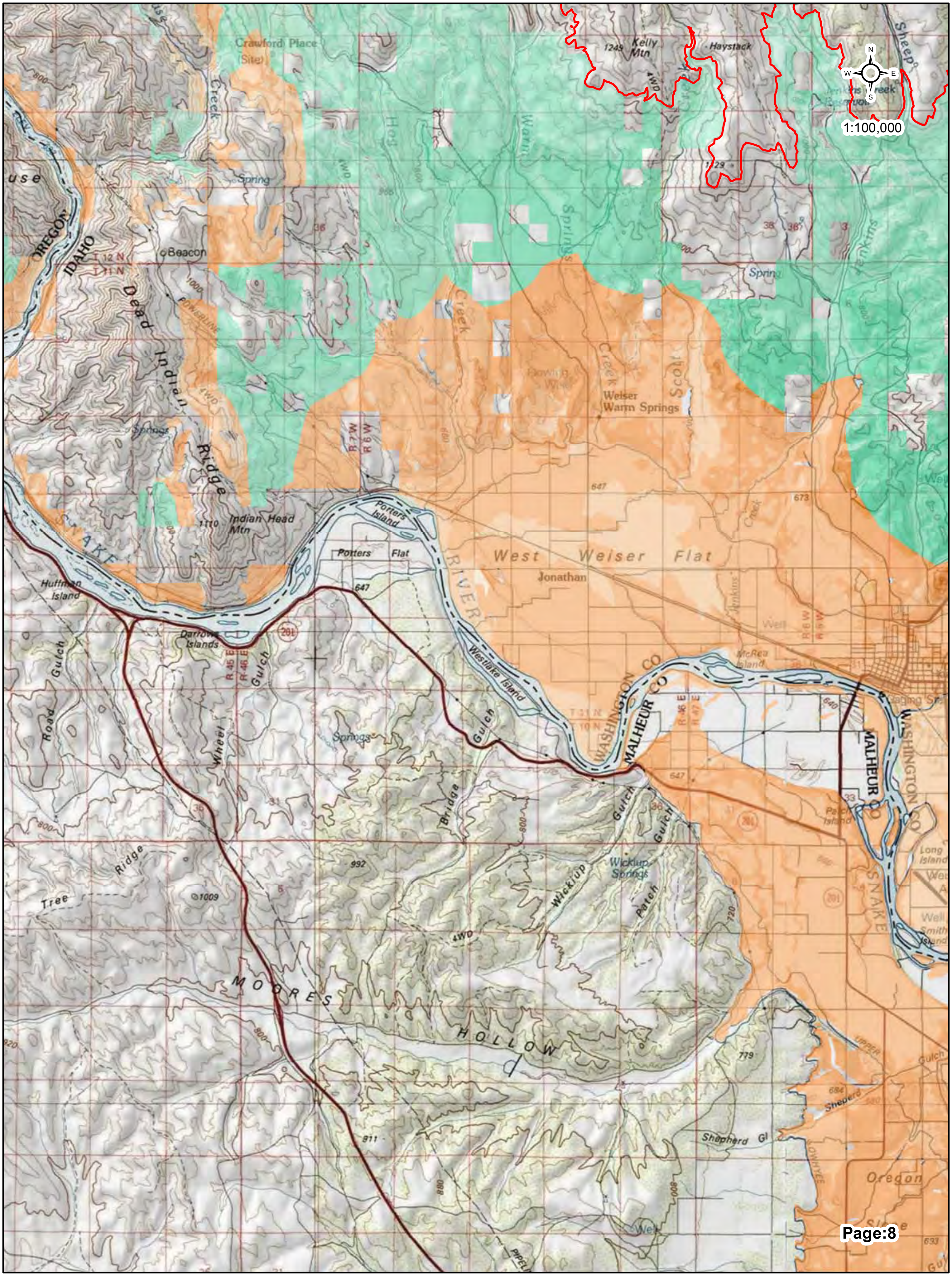

PAYETTE NATIONAL FOREST
N
W
E
S
1:100,000
OREGON
IDAHO
BROWNLEE
BAKER CO
WASHINGTON CO
Sugarloaf Mountain
1871
Snake River Mine
Conner Creek Mine
Connor
Big Hill
1846
McChard Butte
Iron Mtn
1979
Mortimer Mine
Monroe Butte
Mine
Hitt Mts
FOREST
PAYETTE NATIONAL
Springs
Spring
Daly
Quicksand
Creek
Fork
Sturgill
Benton
Sumac
4WD
T 16 N
T 15 N
T 14 N
T 11 S
T 12 S
R 6 W
1297
1673
1253
1222
1516
633

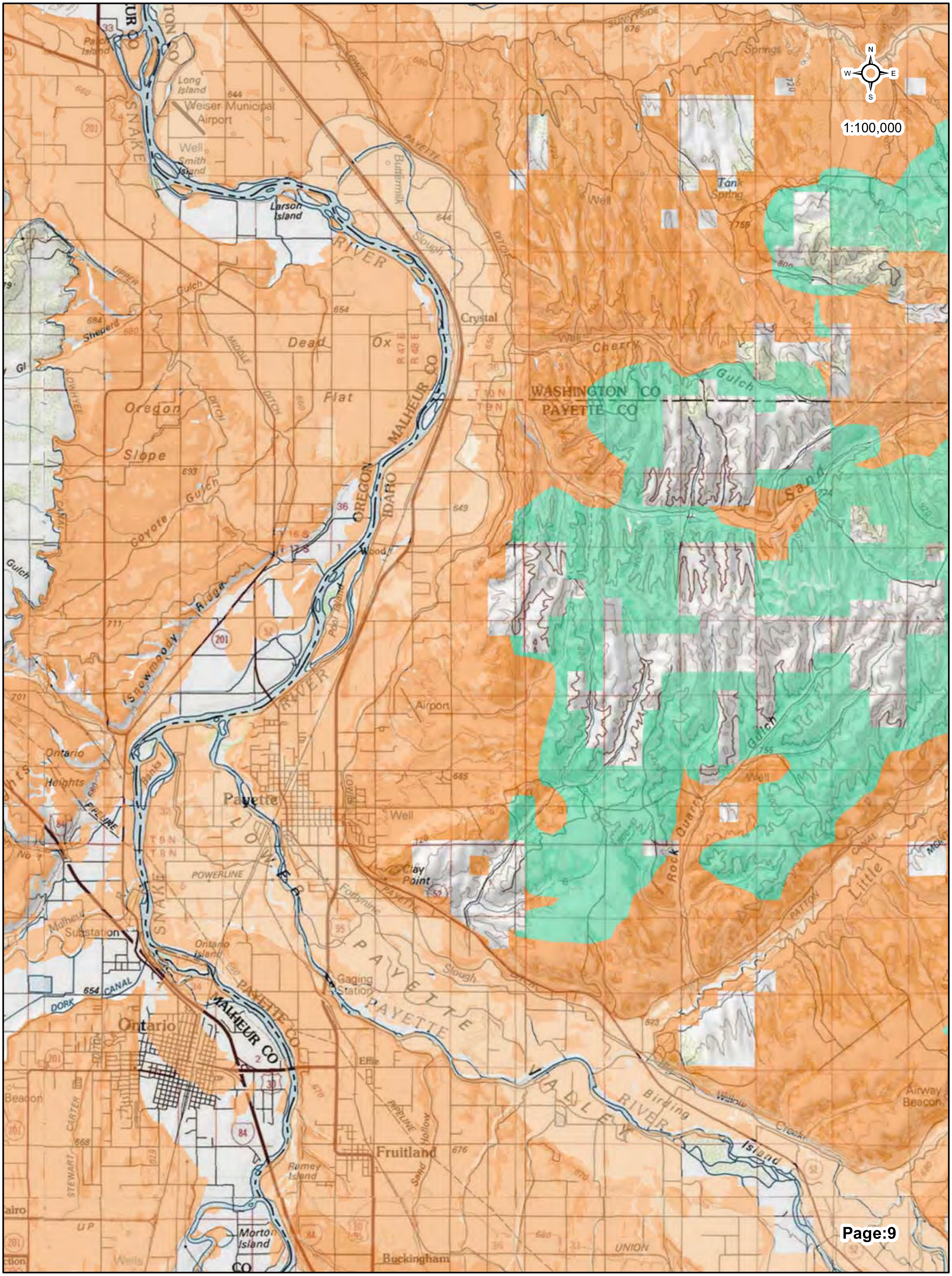


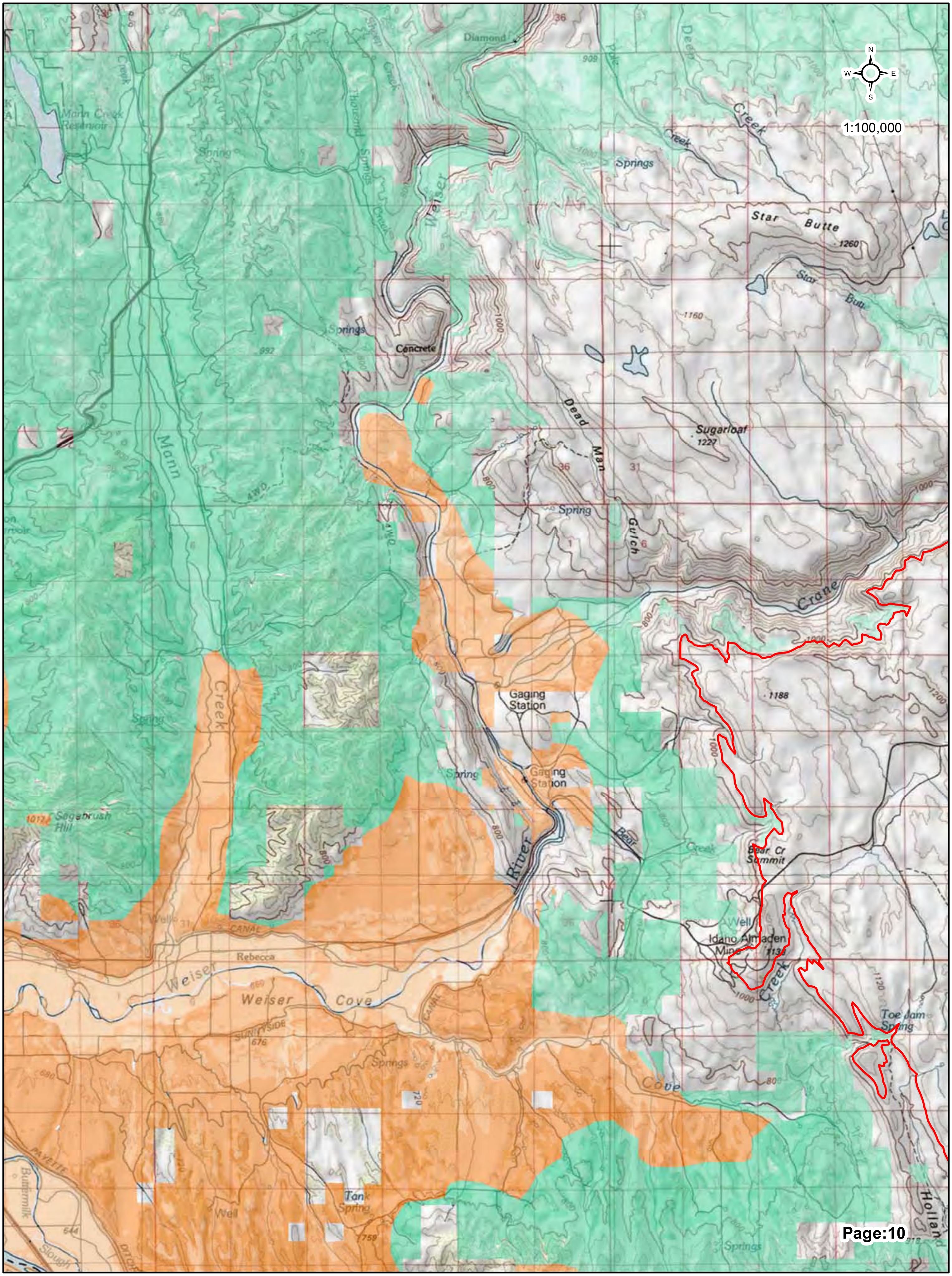
1:100,000
Morgan Mtn
Beacon
Huntington
Slaughterhouse
Range
BAKER CO
WASHINGTON CO
BROWNLEE RES
OREGON
IDAHO
Dead Indian Ridge
Crawford Place
Perkins
Henley Basin
Lost Tom Mtn
Benson
Valley
Chicken
Adobe Gulch
BAKER CO
MALHEUR CO
Striped Mtn
Brosman
Indian Head Mtn
Potters Flat
SNAKE
Springs
Spring
Rock
Creek

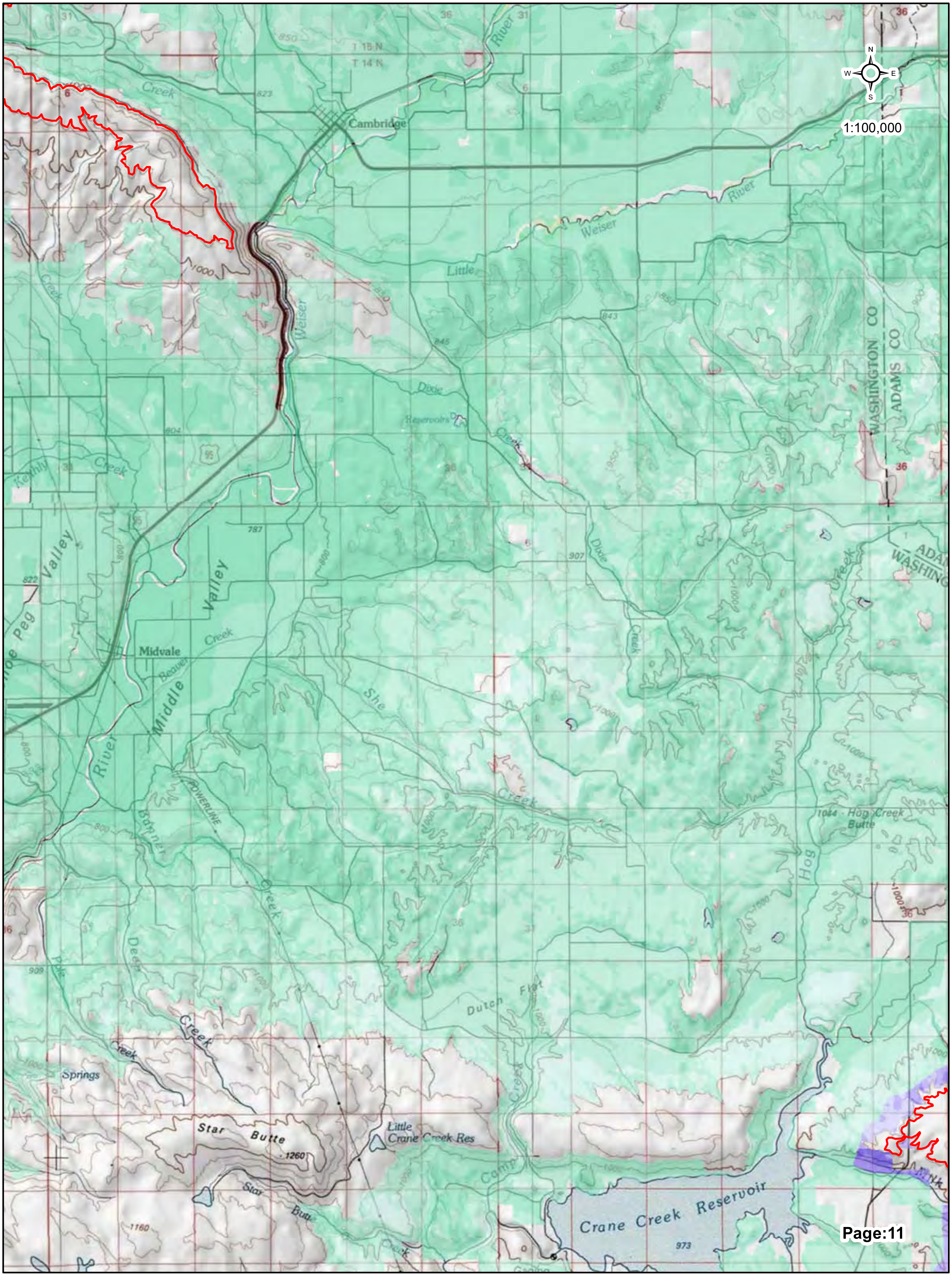


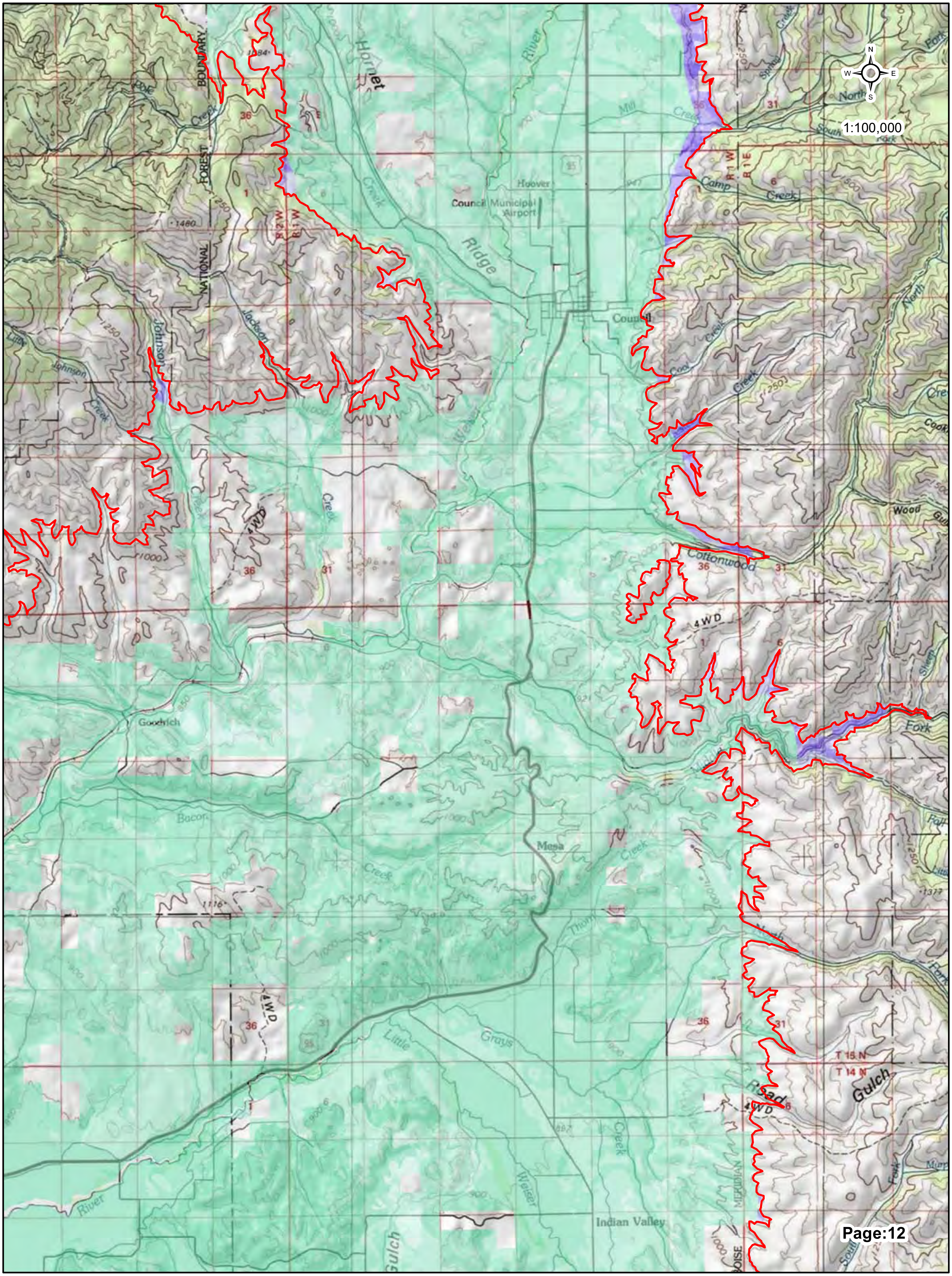
1:100,000
Durkee
Burnt
Durkee
Valley
River
Swayze
Gravel
Pits
Canyon
Gaging
Station
Iron Mtn
Oxman
UNION
PACIFIC
Celia Spring
Manning
Gold
Fork
Sheep Mtn
1615
Mine
Gold Hill
1281
Gold Hill
Spring
RATTLESNAKE SPRINGS
STATE WAYSIDE PARK
Quarry
Gold
Ridge
Gold Ridge
Mine
Lost
Basin
Baldy
Mtn
1662
Baldy Mtn
Mine
Weatherby
Fur
Mountain
Juniper
Mtn
Weatherby
Mtn
Upper Turner
Lower
Pedro
Mountain
North
Fork
Tater Patch
Gulch
Cochran
Kitchen
Weber
Gulch
Spring
Thornton
Gulch
Burnt Cabin
Robinson
South
Fork
Black Rock
Bowman
Creek

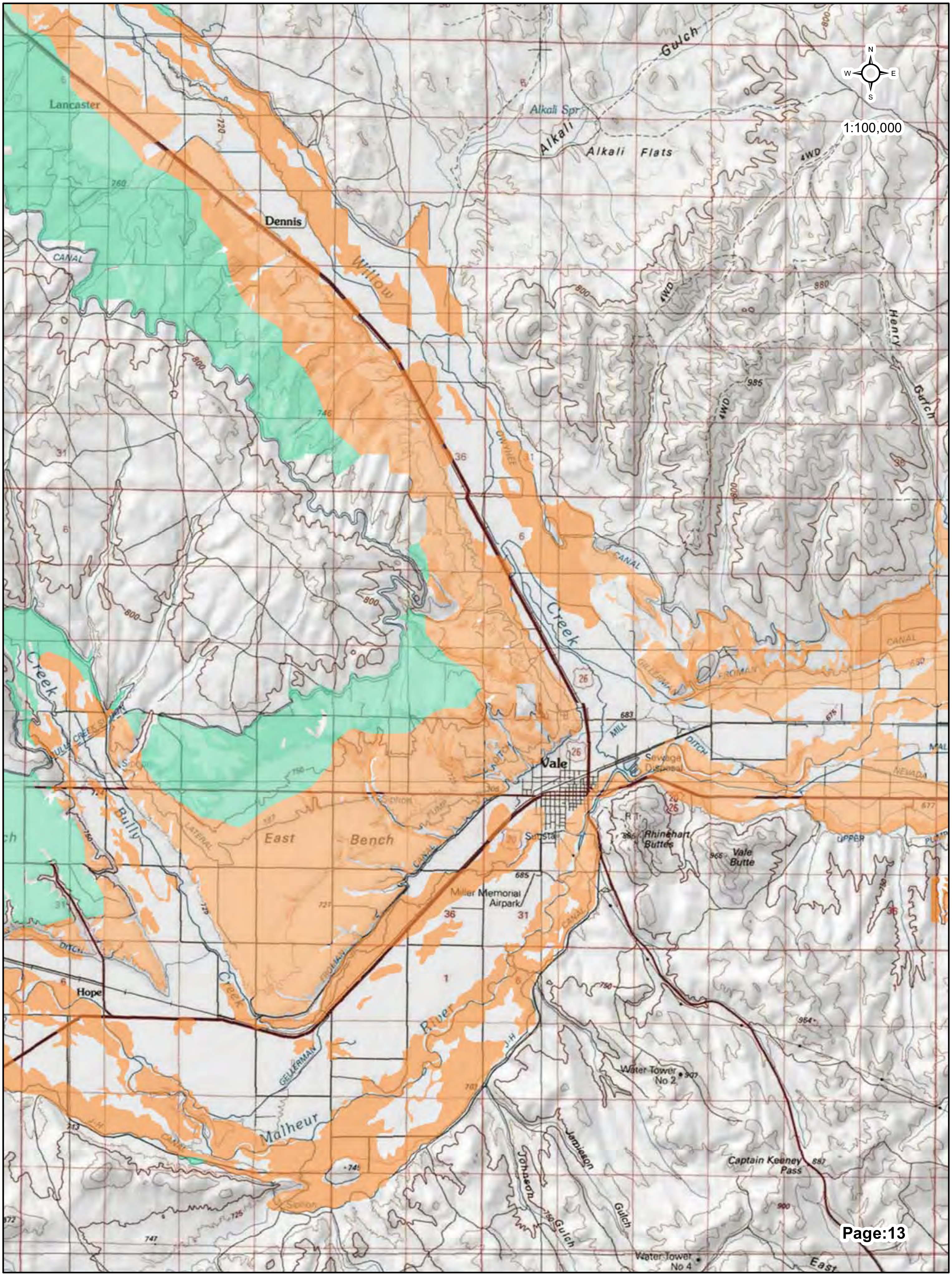

1:100,000
Crawford Place Site
Kelly Mtn
Haystack
Beacon
OREGON
IDAHO
T 12 N
T 11 N
Dead Indian Ridge
Indian Head Mtn
SNAKE RIVER
Porters Island
Potters Flat
Huffman Island
Darrows Islands
Weiser Warm Springs
West Weiser Flat
Jonathan
Westlake Island
McRea Island
WASHINGTON CO
MALHEUR CO
Wheel Gulch
Bridge Gulch
Wickiup Springs
Wickiup
Patch Gulch
Tree Ridge
Road Gulch
MOORES HOLLOW
Shepherd Gl
Long Island
Smith Island
Oregon Slope
R 7 W
R 6 W
R 45 E
R 46 E
R 47 E
T 11 N
T 10 N
Page:8


1:100,000
N
S
E
W
Weiser Municipal Airport
Long Island
Smith Island
Larson Island
SNAKE
RIVER
Buttermilk Slough
Crystal
Dead Ox Flat
Oregon Slope
Coyote Gulch
Snowmoody Ridge
WASHINGTON CO
PAYETTE CO
MALHEUR CO
OREGON
IDAHO
Cherry Gulch
Sand
Rock Quarry
Gulch
Tank Spring
Airport
Payette
LOWER
POWERLINE
Clay Point
Ontario Heights
Substation
Ontario Island
Gaging Station
PAYETTE
VALLEY
Ontario
DORK CANAL
Fruitland
Morton Island
Ramey Island
Sand Hollow
Effie
Buckingham
UNION
Birding Island
Willow Creek
Airway Beacon
PATTON
Little
Beacon
Cairo
STEWART
CARTER


1:100,000
N
S
E
W
Diamond
Mann Creek Reservoir
Thousand Springs Creek
Sheep Creek
Deep Creek
Pole Creek
Springs
Star Butte
1260
Weiser
Concrete
Springs
1160
Sugarloaf
1227
Dead Man Gulch
Mann
Spring
Crane
Gaging Station
Gaging Station
1188
Creek
Sagebrush Hill
River
Bear Creek
Bear Cr Summit
Idaho Almaden Mine
Well
Rebecca
Weiser
Weiser Cove
Sunnyside
Springs
Cove
Toe Jam Spring
Tank Spring
Well
Buttermilk Slough
Holland
Page:10


N
W
E
S
1:100,000
T 15 N
T 14 N
Cambridge
Weiser River
Little Weiser River
Dixie Creek
Reservoirs
WASHINGTON CO
ADAMS CO
Keithly Creek
Valley
Middle Valley
Midvale
Beaver Creek
She Creek
POWERLINE
Banner Creek
Hog Creek
Hog Creek Butte
Deer Creek
Dutch Flat
Springs
Star Butte
Little Crane Creek Res
Camp Creek
Crane Creek Reservoir
973
1260


1:100,000
Council
Council Municipal Airport
Hoover
Hornet
Ridge
Creek
River
Mill Creek
Camp Creek
Cottonwood
Johnson
Jackson
NATIONAL FOREST BOUNDARY
Goodrich
Bacon
Mesa
Little
Grays
Weiser
River
Indian Valley
Gulch
Road
4WD
R 2 W
R 1 W
R 1 E
T 15 N
T 14 N
Wood Gulch
Fork
BOISE MERIDIAN
Page:12



N
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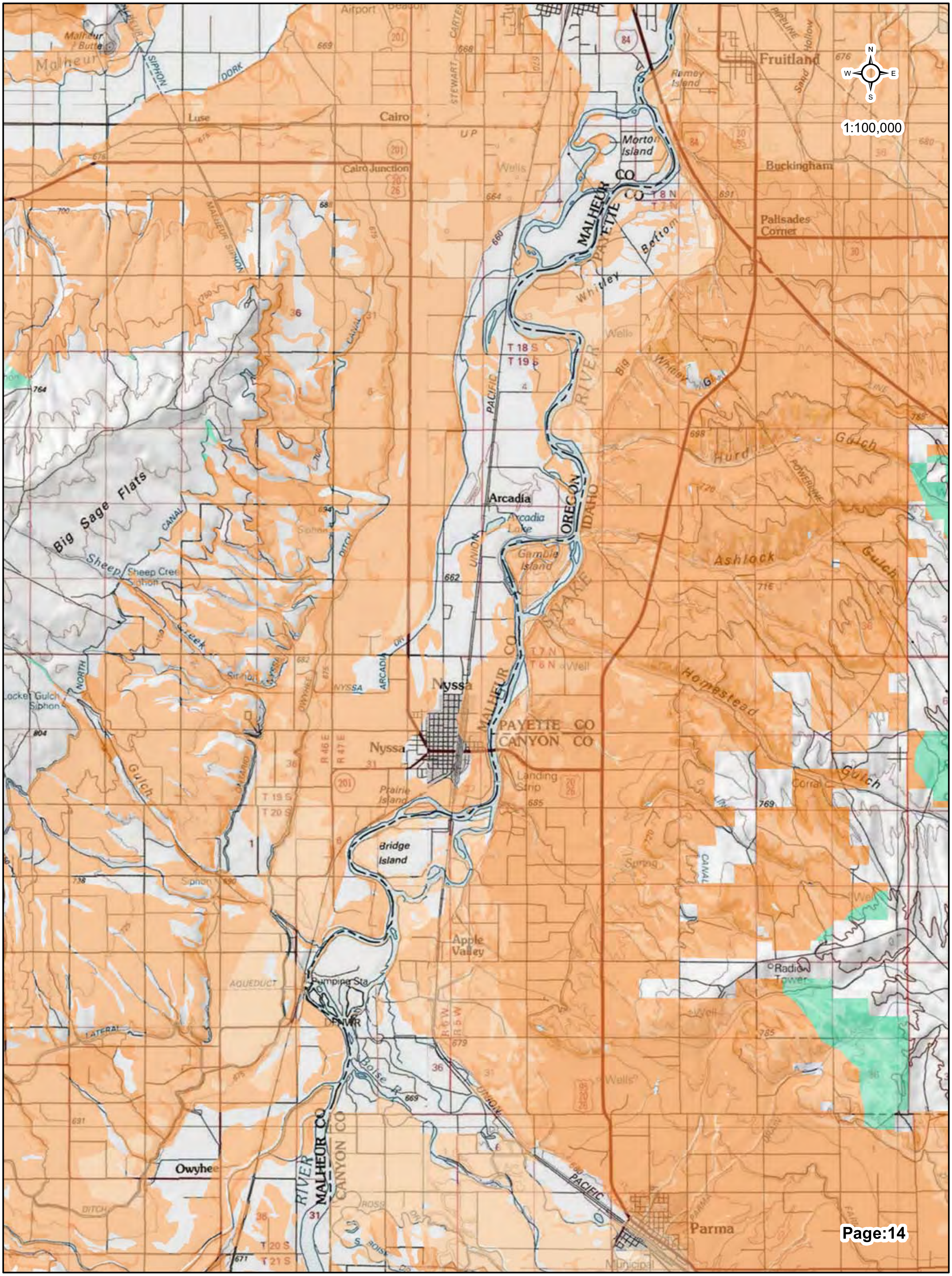
1:100,000
Lancaster
Dennis
Alkali Spr
Alkali
Alkali Flats
Gulch
Willow
Creek
Henry
Gulch
CANAL
Vale
East
Bench
Bully
Creek
Hope
Malheur
River
Sewage Disposal
Rhinehart Buttes
Vale Butte
Miller Memorial Airpark
Water Tower No 2
Water Tower No 4
Captain Keeney Pass
Johnson
Jamieson
Gulch
East



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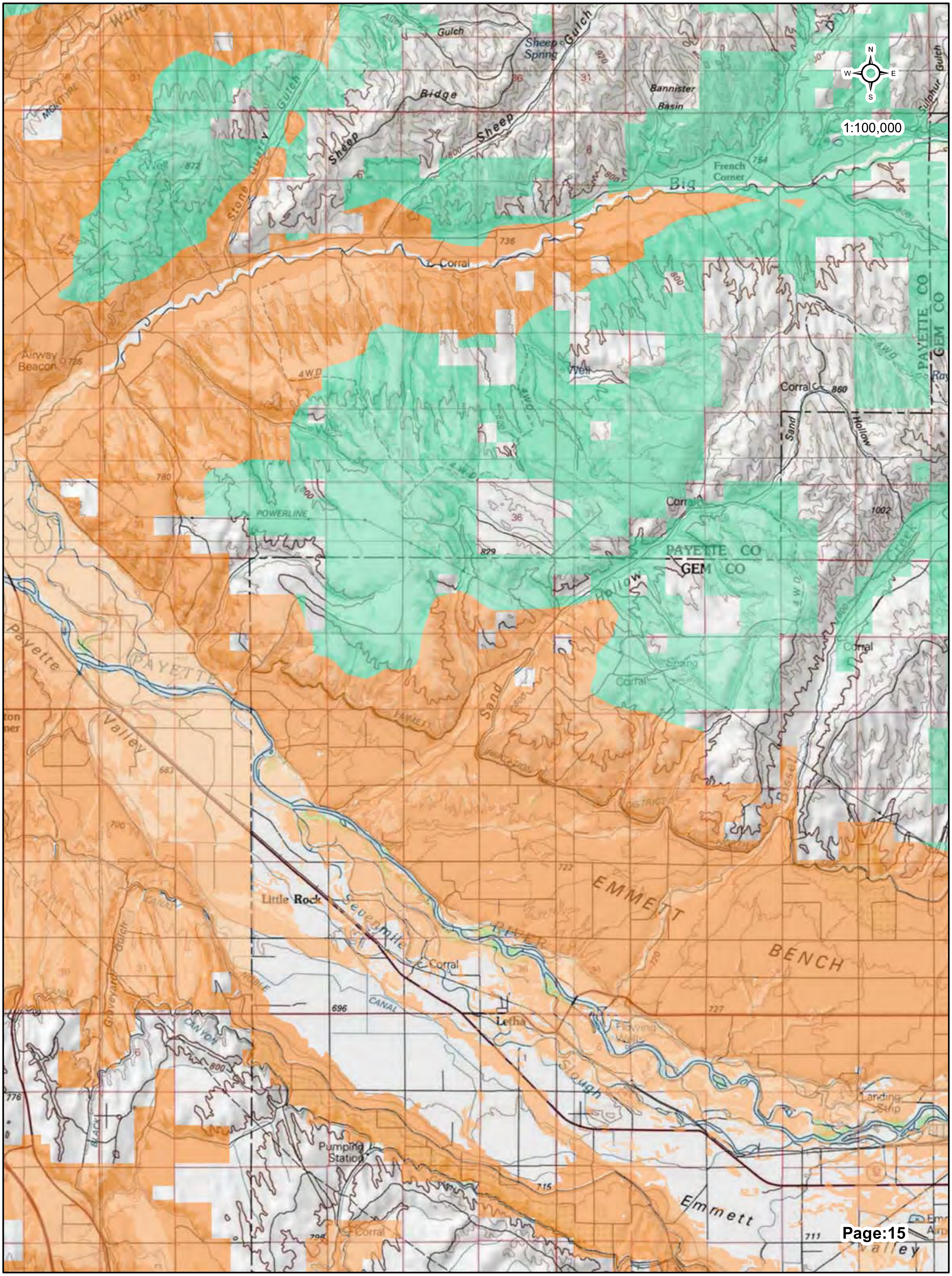
Malheur Butte
Malheur
Airport
Luse
Cairo
Cairo Junction
Fruitland
Remey Island
Morton Island
Buckingham
Palisades Corner
MALHEUR CO
PAYETTE CO
Bottom
Whitley
Big Sage Flats
Sheep Creek Siphon
Locket Gulch Siphon
Arcadia
Arcadia Lake
Gamble Island
OREGON
IDAHO
SNAKE RIVER
Hurd Gulch
Ashlock Gulch
Homestead Gulch
Corral Gulch
Nyssa
PAYETTE CO
CANYON CO
Landing Strip
Prairie Island
Bridge Island
Apple Valley
Pumping Sta
Radio Tower
Boise R
Owyhee
MALHEUR CO
CANYON CO
Parma
Municipal
Page:14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N
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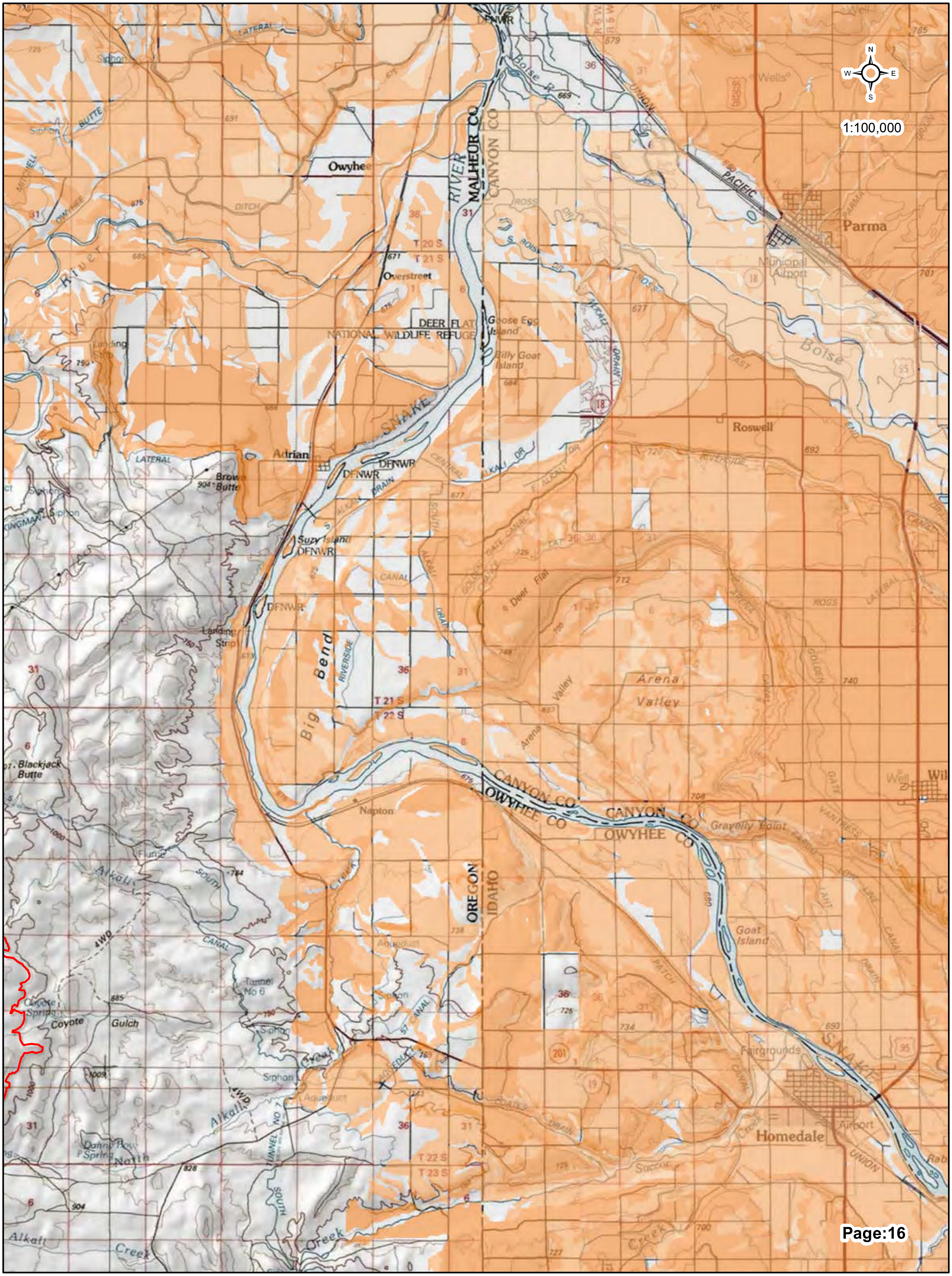
Sheep Spring
Gulch
Bridge
Sheep
Bannister Basin
French Corner
Big
Stone Quarry Gulch
Well
Corral
Airway Beacon
4WD
POWERLINE
PAYETTE CO
GEM CO
Hollow
Sand
Corral
Spring
Payette
PAYETTE
Valley
Little Rock
Sevenmile
RIVER
EMMETT
BENCH
Corral
Letha
Flowing Wells
Slough
Landing Strip
Pumping Station
Emmett
Valley
Gravelyard Gulch
CANAL
CANYON
DISTRICT
Bissel
Sulphur Gulch


N
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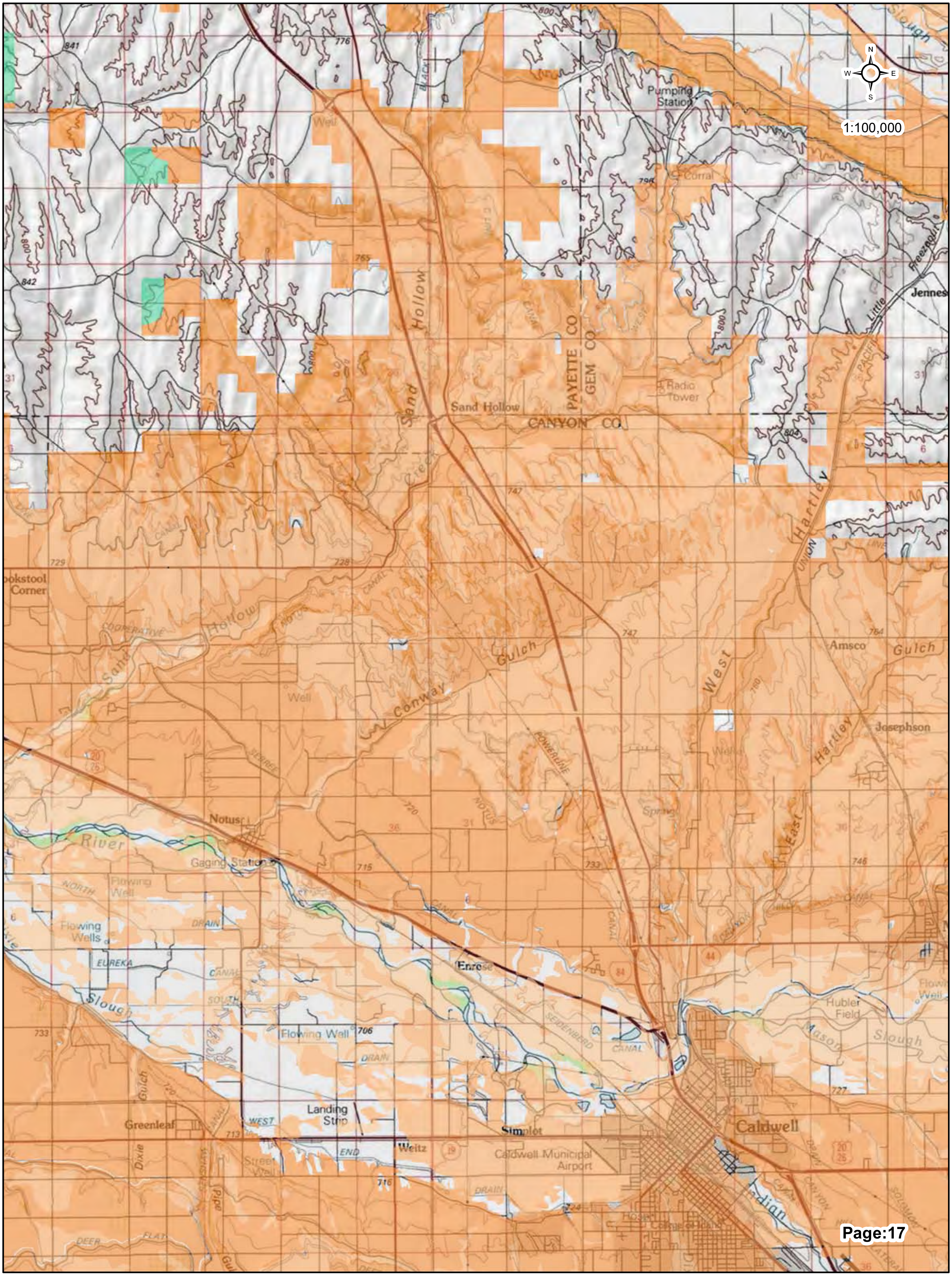
1:100,000
Owyhee
Parma
Municipal Airport
Wells
UNION
PACIFIC
Bolse R
MALHEUR CO
CANYON CO
RIVER
SNAKE
Overstreet
DEER FLAT
NATIONAL WILDLIFE REFUGE
Goose Egg Island
Billy Goat Island
Roswell
Adrian
DFNWR
Brown Butte
LATERAL
Suzy Island
Landing Strip
Deer Flat
Arena Valley
Big Bend
RIVERSIDE
T 20 S
T 21 S
T 22 S
T 23 S
Blackjack Butte
Napton
CANYON CO
OWYHEE CO
Gravelly Point
OREGON
IDAHO
Goat Island
Aqueduct
Tunnel No 6
Coyote Spring
Coyote
Gulch
Siphon
Fairgrounds
Homedale
Airport
Danny Boy Spring
North
Alkali
Creek
Succor
4WD
Page:16



N
W
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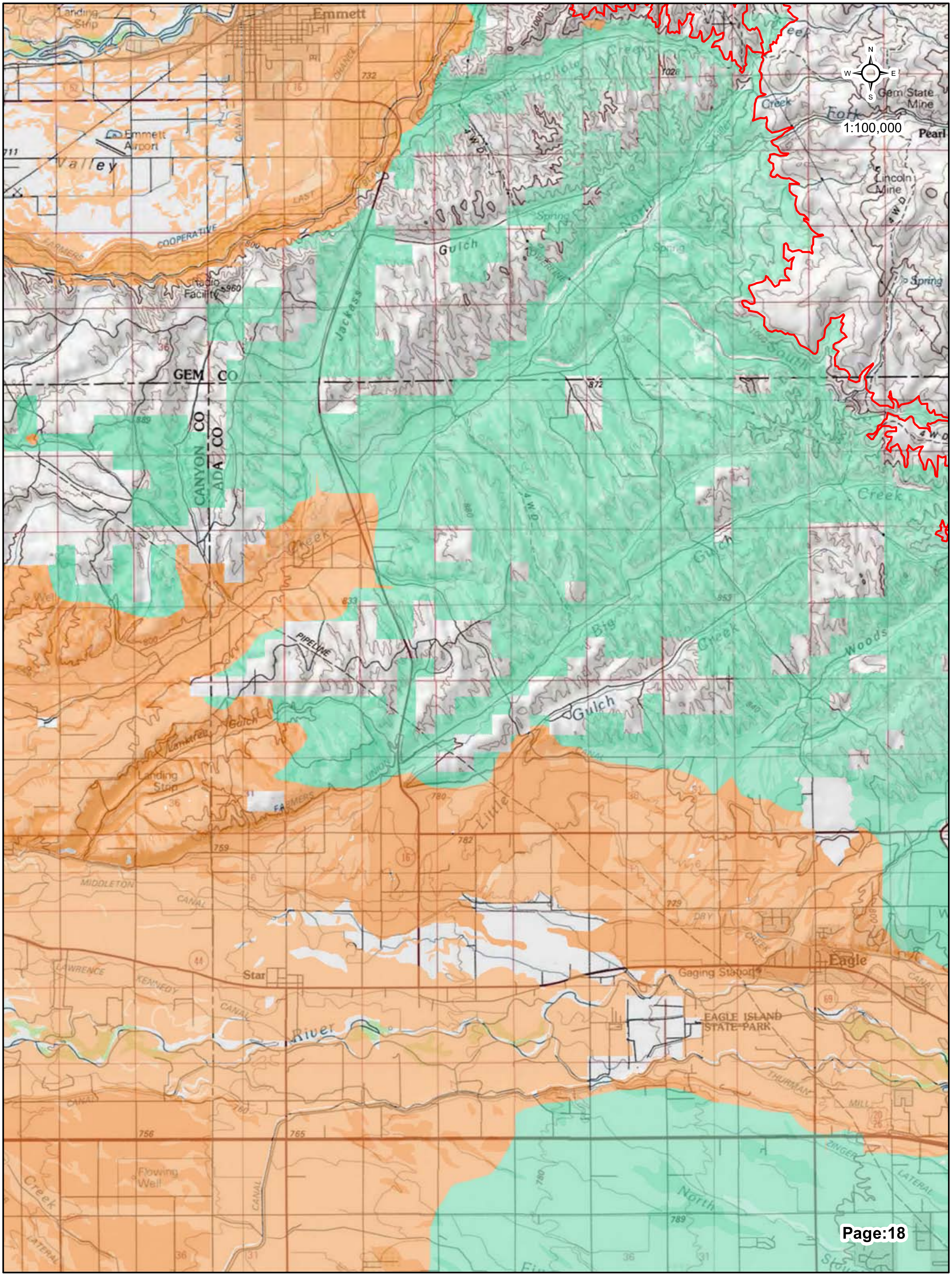
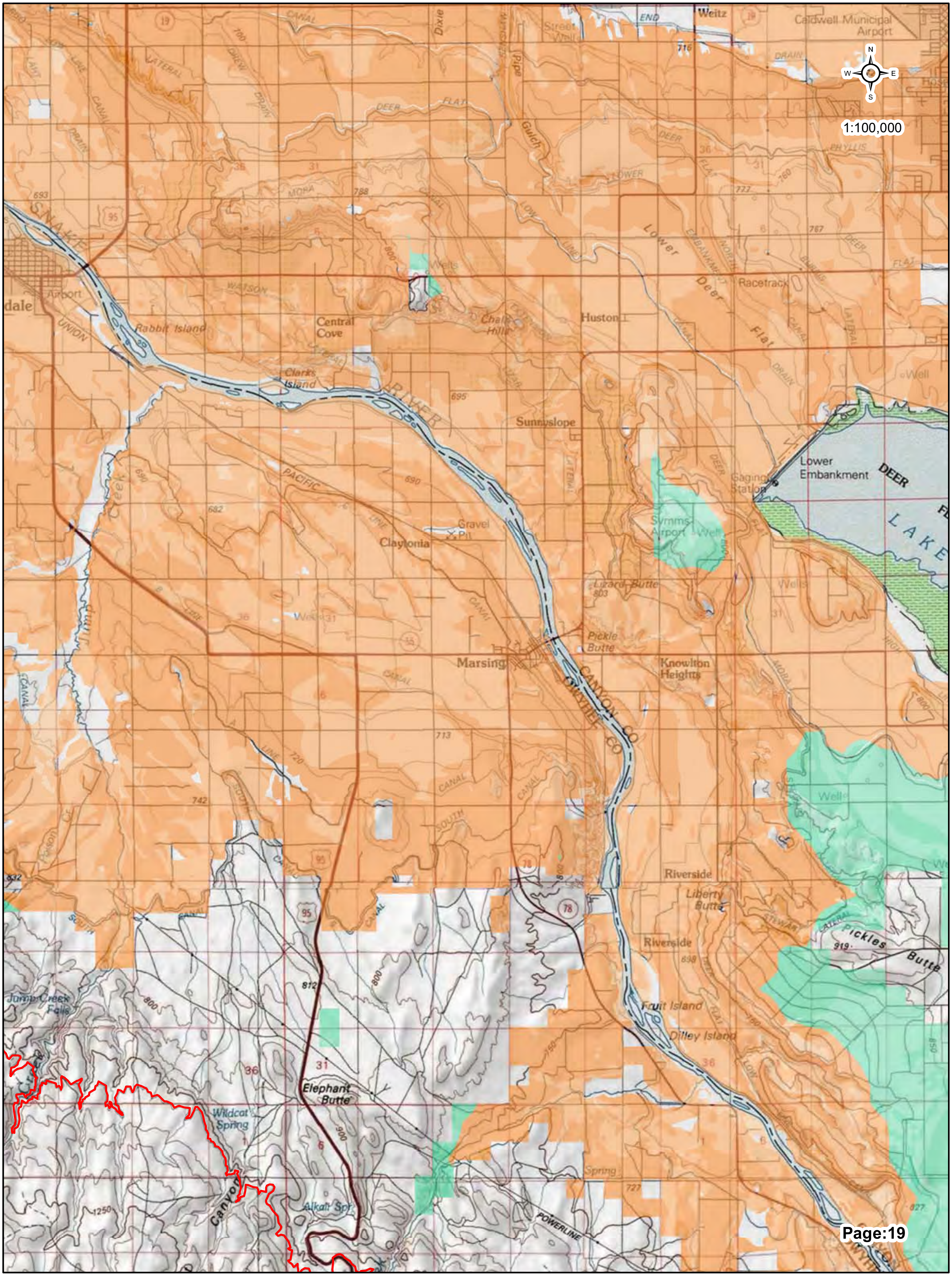
1:100,000
Pumping Station
Corral
Well
Sand Hollow
PAYETTE CO
GEM CO
CANYON CO
Radio Tower
Spring
Sand Hollow Creek
Hartley
Little Freezeout
Jennes
Conway Gulch
Sand Hollow
ookstool Corner
COOPERATIVE CANAL
West
Amsco
Gulch
Josephson
East Hartley
Notus
River
Gaging Station
Flowing Well
Flowing Wells
EUREKA
Enrese
Slough
Flowing Well
Hubler Field
Mason Slough
Landing Strip
Greenleaf
Dixie
Gulch
Simplot
Weitz
Caldwell
Caldwell Municipal Airport
Indian


1:100,000
Emmett
Emmett Airport
Valley
Gem State Mine
Pearl
Lincoln Mine
GEM CO
CANYON CO
ADA CO
Jackass
Gulch
Big Creek Gulch
Woods
Little
Star
Eagle
Gaging Station
EAGLE ISLAND STATE PARK
River
Landing Strip
Flowing Well
MIDDLETON
CANAL
FARMERS
PIPELINE
North



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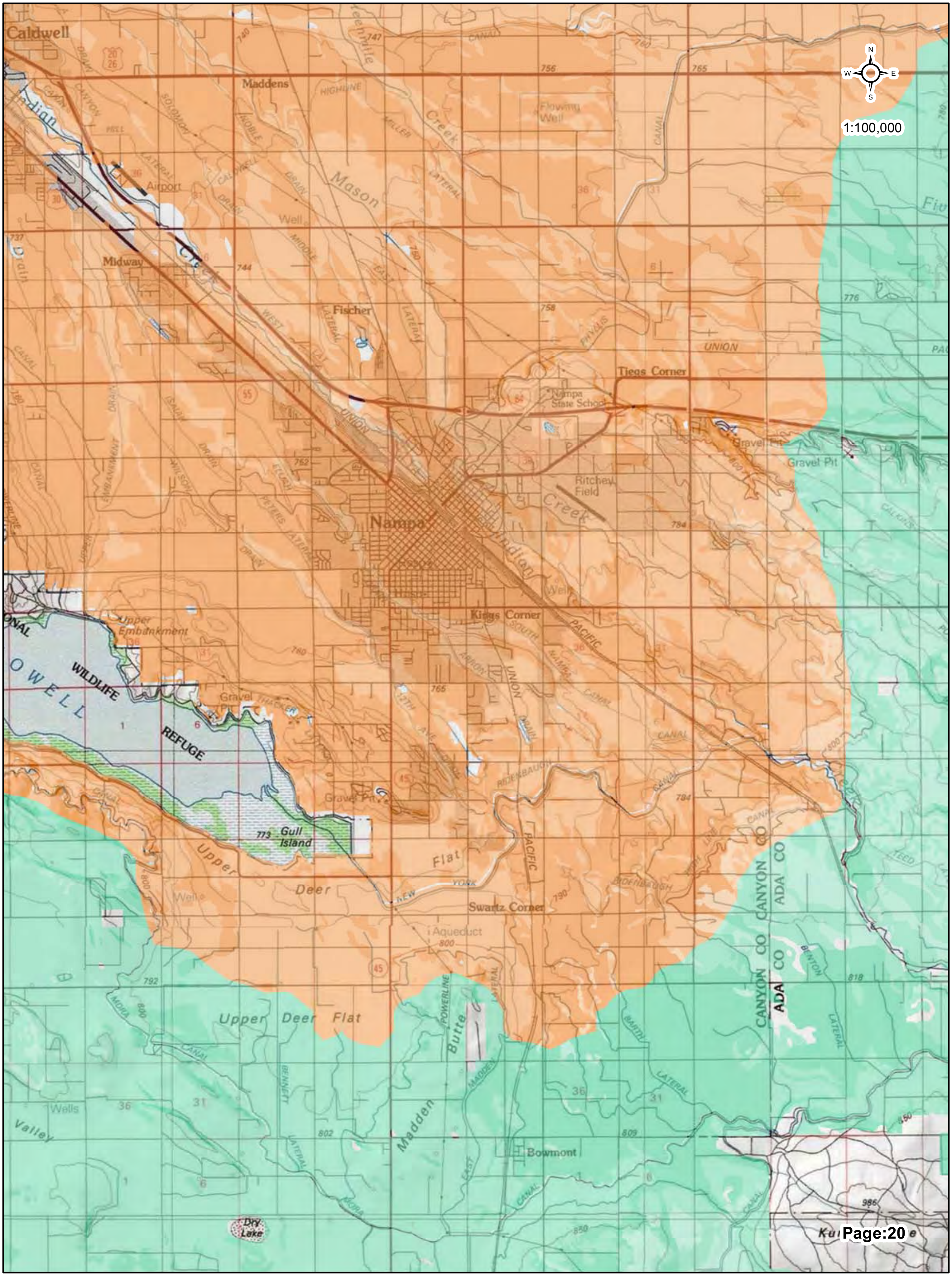
Caldwell Municipal Airport
Weitz
Lower Deer Flat
Racetrack
Huston
Central Cove
Chalk Hill
Rabbit Island
Clarks Island
SNAKE RIVER
Sunnyslope
Lower Embankment
Gaging Station
DEER FLAT
LAKE
Symms Airport
Gravel Pit
Claytonia
Lizard Butte
Pickle Butte
Marsing
Knowlton Heights
CANYON CO
OWYHEE CO
Riverside
Liberty Butte
Pickles Butte
Fruit Island
Dilley Island
Jump Creek Falls
Wildcat Spring
Elephant Butte
Alkali Spr
POWERLINE
Page:19


N
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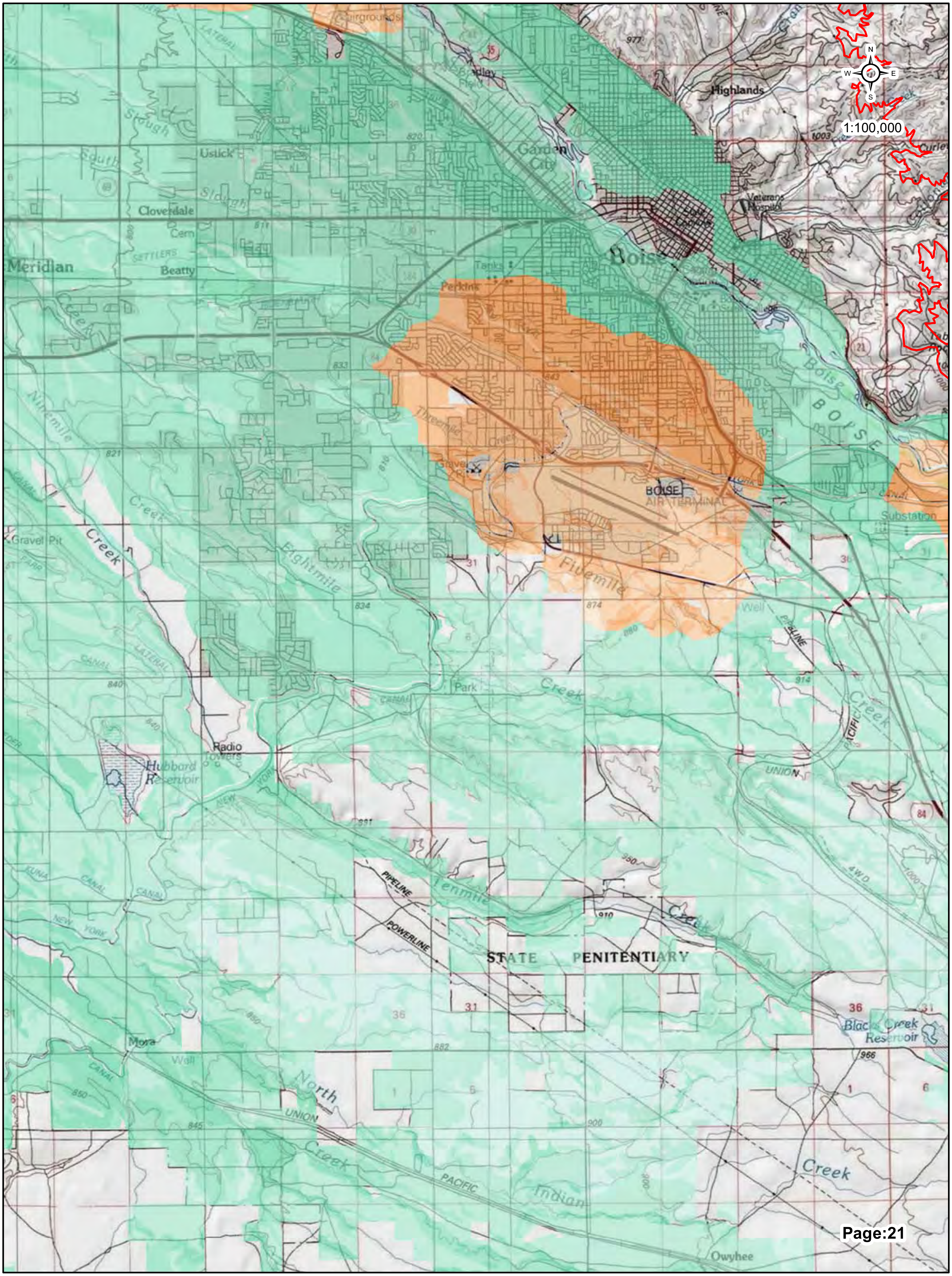
1:100,000
Caldwell
Maddens
Flowing Well
Mason
Creek
Airport
Midway
Fischer
Tiegs Corner
Nampa State School
Gravel Pit
Ritchey Field
Nampa
Kings Corner
Upper Embankment
WILDLIFE
REFUGE
Gull Island
Upper Deer Flat
Swartz Corner
Aqueduct
Madden Butte
Bowmont
Dry Lake
CANYON CO
ADA CO
UNION
PACIFIC


1:100,000
N
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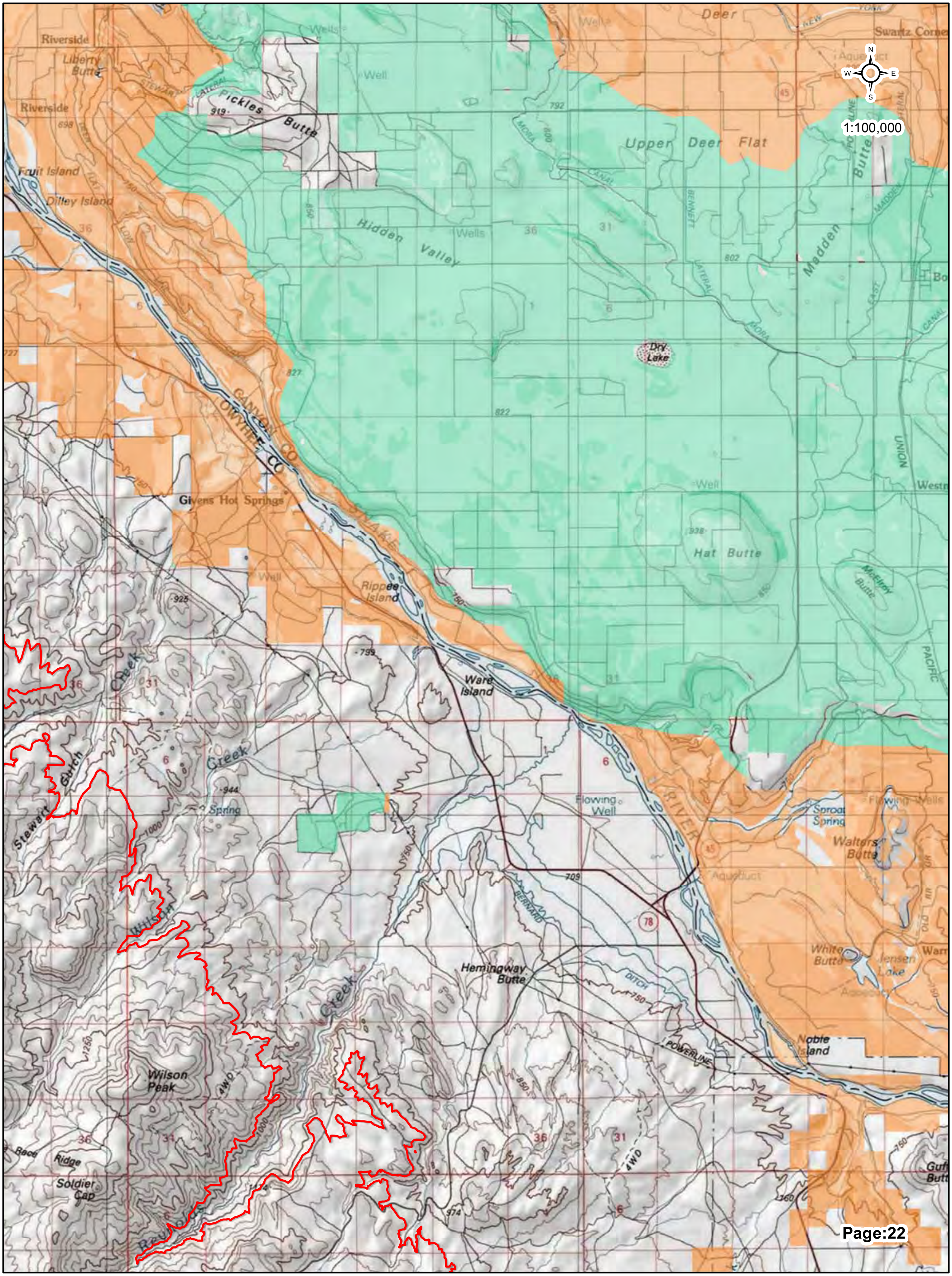
Highlands
Garden City
Ustick
Cloverdale
Meridian
Beatty
Boise
Veterans Hospital
Perkins
Tanks
BOISE AIR TERMINAL
Substation
Gravel Pit
Eightmile
Fivemile
Threemile
Park
Radio Towers
Hubbard Reservoir
PIPELINE
POWERLINE
STATE PENITENTIARY
Black Creek Reservoir
Mora
Well
North
Creek
UNION
PACIFIC
Indian
Owyhee
Fairgrounds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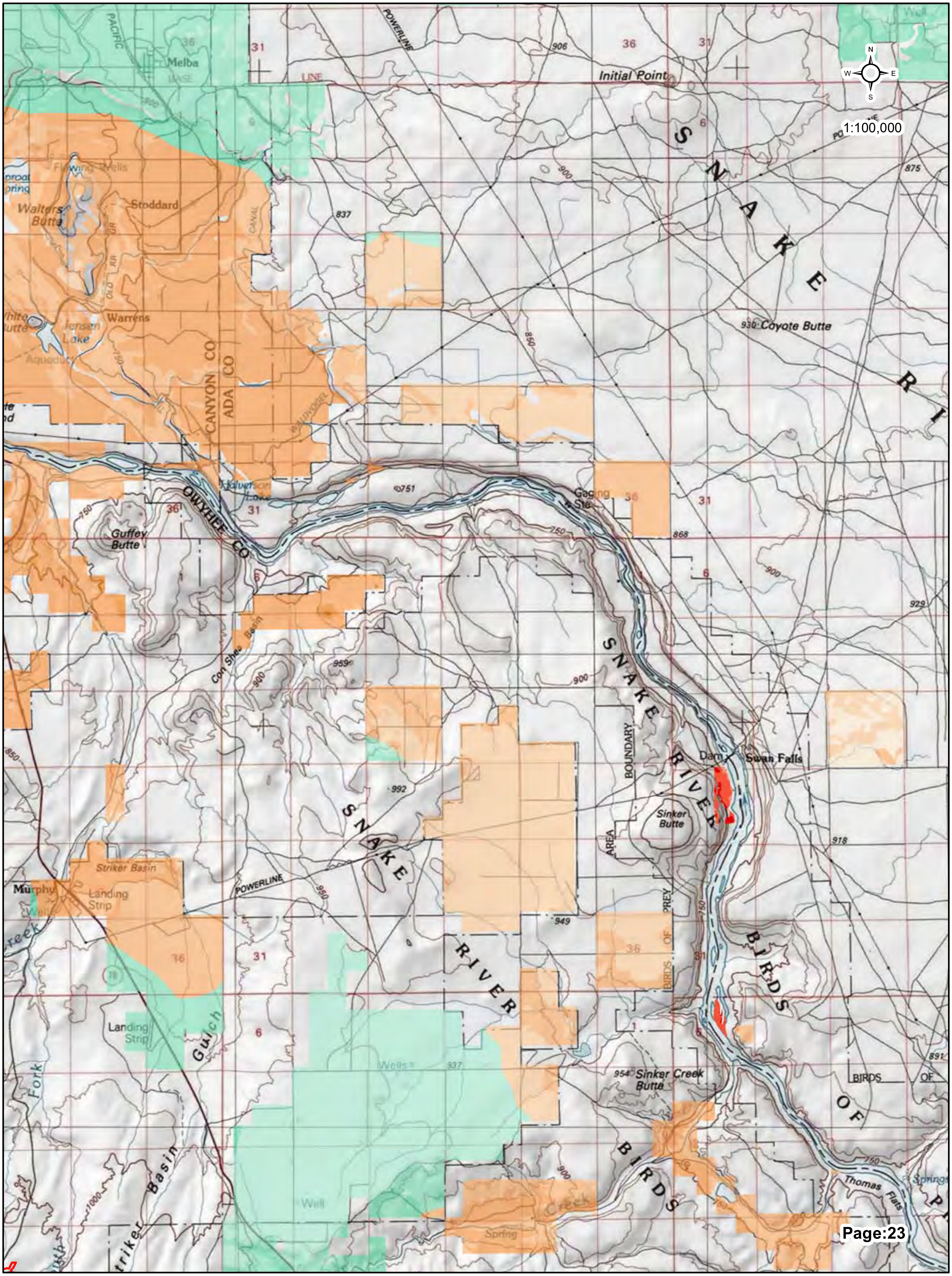
Riverside
Liberty Butte
Pickles Butte
Fruit Island
Dilley Island
Upper Deer Flat
Hidden Valley
Madden
Dry Lake
CANYON CO
OWYHEE CO
Givens Hot Springs
SNAKE RIVER
Hat Butte
McElroy Butte
Rippee Island
Ware Island
Flowing Well
Walters Butte
Hemingway Butte
White Butte
Jensen Lake
Noble Island
Wilson Peak
Stewart Gulch
Race Ridge
Soldier Cap
POWERLINE
UNION PACIFIC
Swartz Corner



Melba
Initial Point
1:100,000
N
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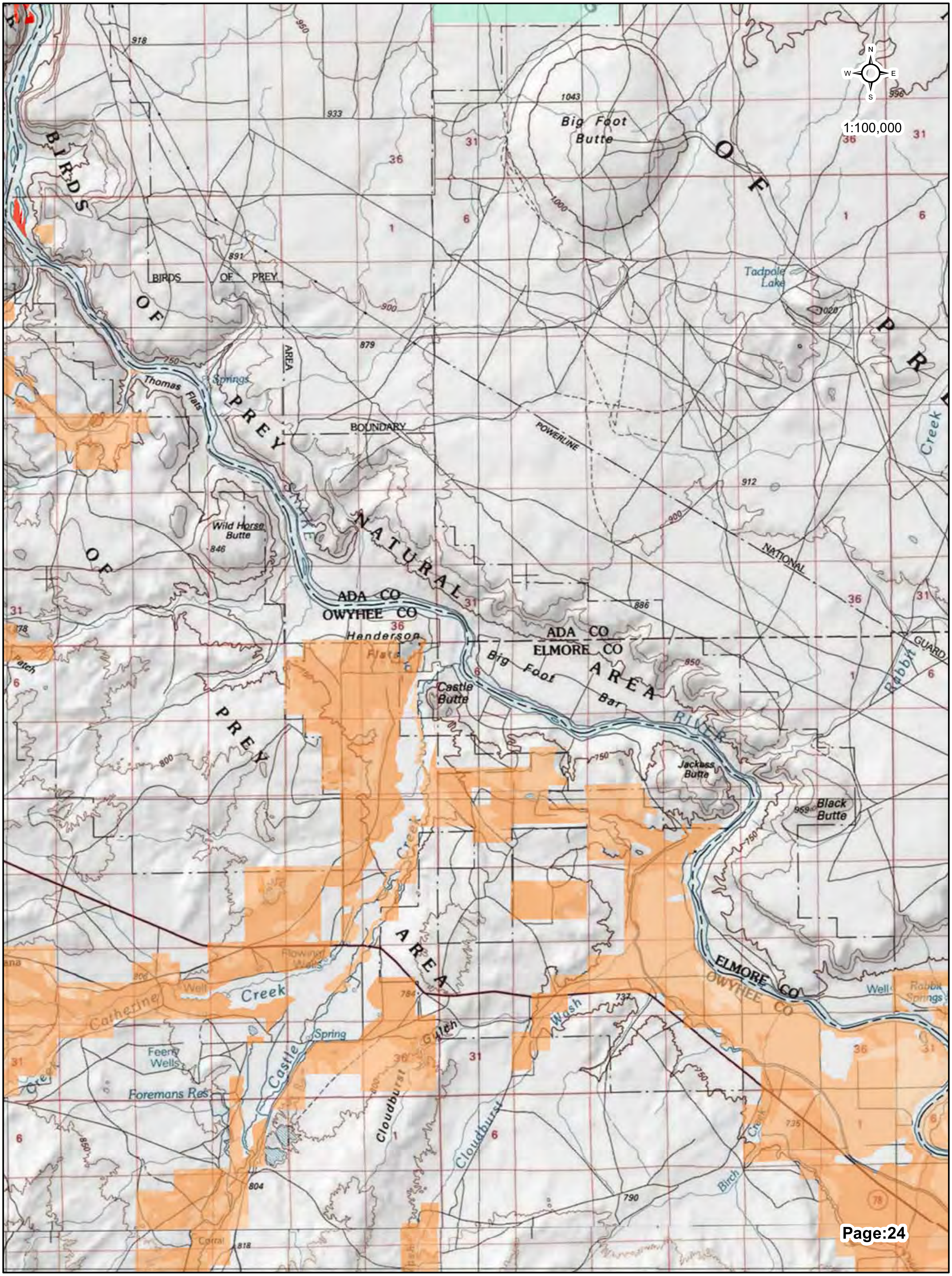
SNAKE RIVER
Stoddard
Walters Butte
Flowing Wells
Warrens
Jensen Lake
CANYON CO
ADA CO
Coyote Butte
POWERLINE
Halverson Lake
OWYHEE CO
Guffey Butte
Gaging Sta
Con Shea Basin
SNAKE RIVER
BOUNDARY
AREA
Dam
Swan Falls
Sinker Butte
Striker Basin
Murphy
Landing Strip
BIRDS OF PREY
Sinker Creek Butte
Wells
Landing Strip
Gulch
Fork
Striker Basin
Well
Spring
Thomas Flats
Springs
BIRDS
Page:23



N
W
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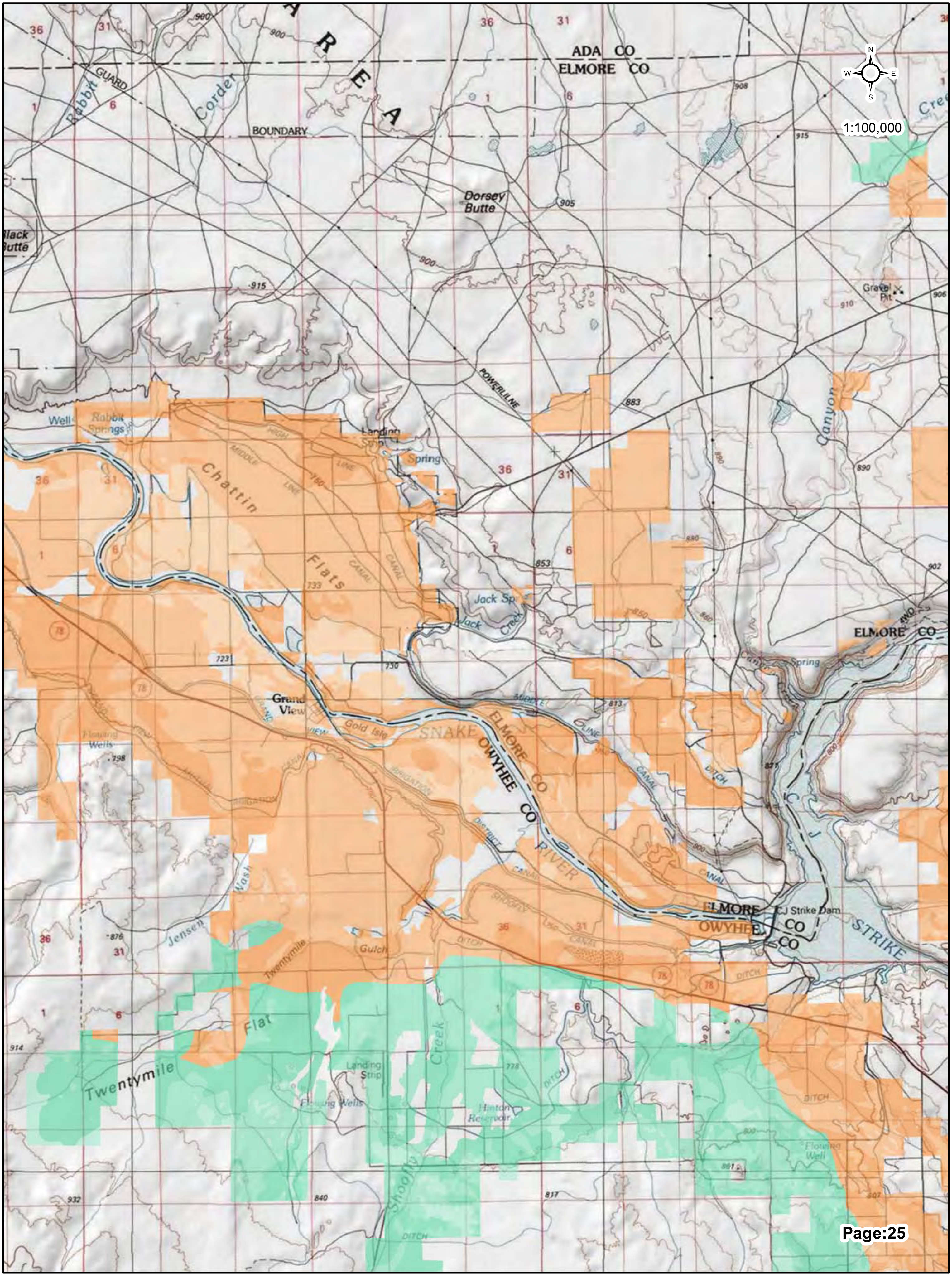
1:100,000
Big Foot Butte
BIRDS OF PREY
BIRDS OF PREY
OF PREY
PREY
BIRDS OF PREY NATURAL AREA
BOUNDARY
AREA
POWERLINE
NATIONAL
GUARD
Tadpole Lake
Thomas Flats
Springs
Wild Horse Butte
SNAKE
RIVER
ADA CO
OWYHEE CO
ADA CO
ELMORE CO
ELMORE CO
OWYHEE CO
Henderson Flats
Castle Butte
Big Foot Bar
Jackass Butte
Black Butte
Creek
Rabbit Creek
Flowing Wells
Catherine Creek
Well
Feeny Wells
Foremans Res
Castle Creek
Spring
Cloudburst Gulch
Cloudburst
Wash
Birch Creek
Rabbit Springs
Corral
Page:24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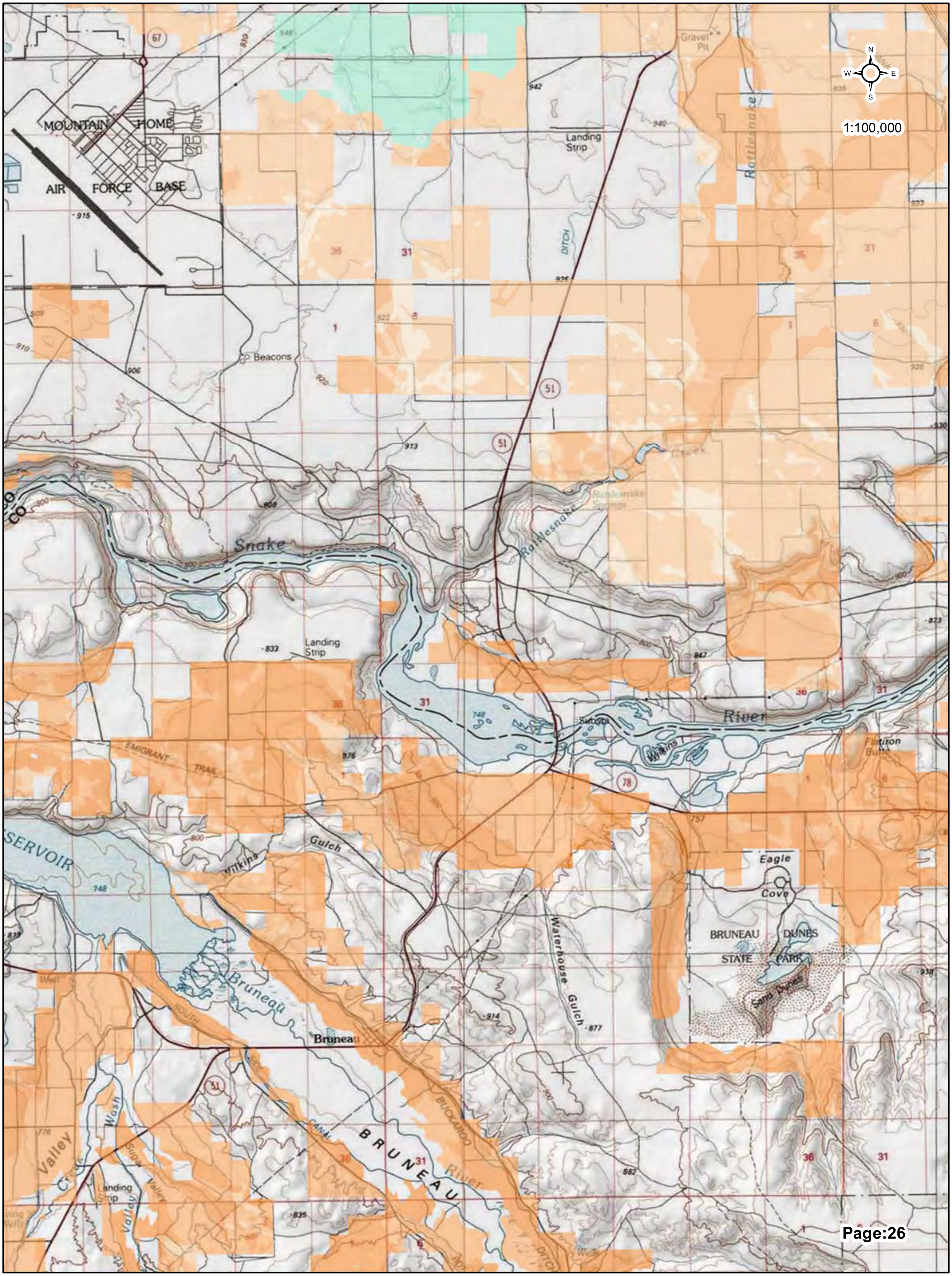
ADA CO
ELMORE CO
BOUNDARY
GUARD
Dorsey Butte
Black Butte
POWERLINE
Chattin Flats
Rabbit Springs
Landing Strip
Spring
Jack Sp
Jack Creek
Grand View
Gold Isle
SNAKE RIVER
ELMORE CO
OWYHEE CO
Canyon
C J STRIKE
CJ Strike Dam
Gravel Pit
Spring
Flowing Wells
Jensen Wash
Twentymile Gulch
Twentymile Flat
Landing Strip
Flowing Wells
Creek
Hinton Reservoir
Flowing Well
Shoofly
Page:25



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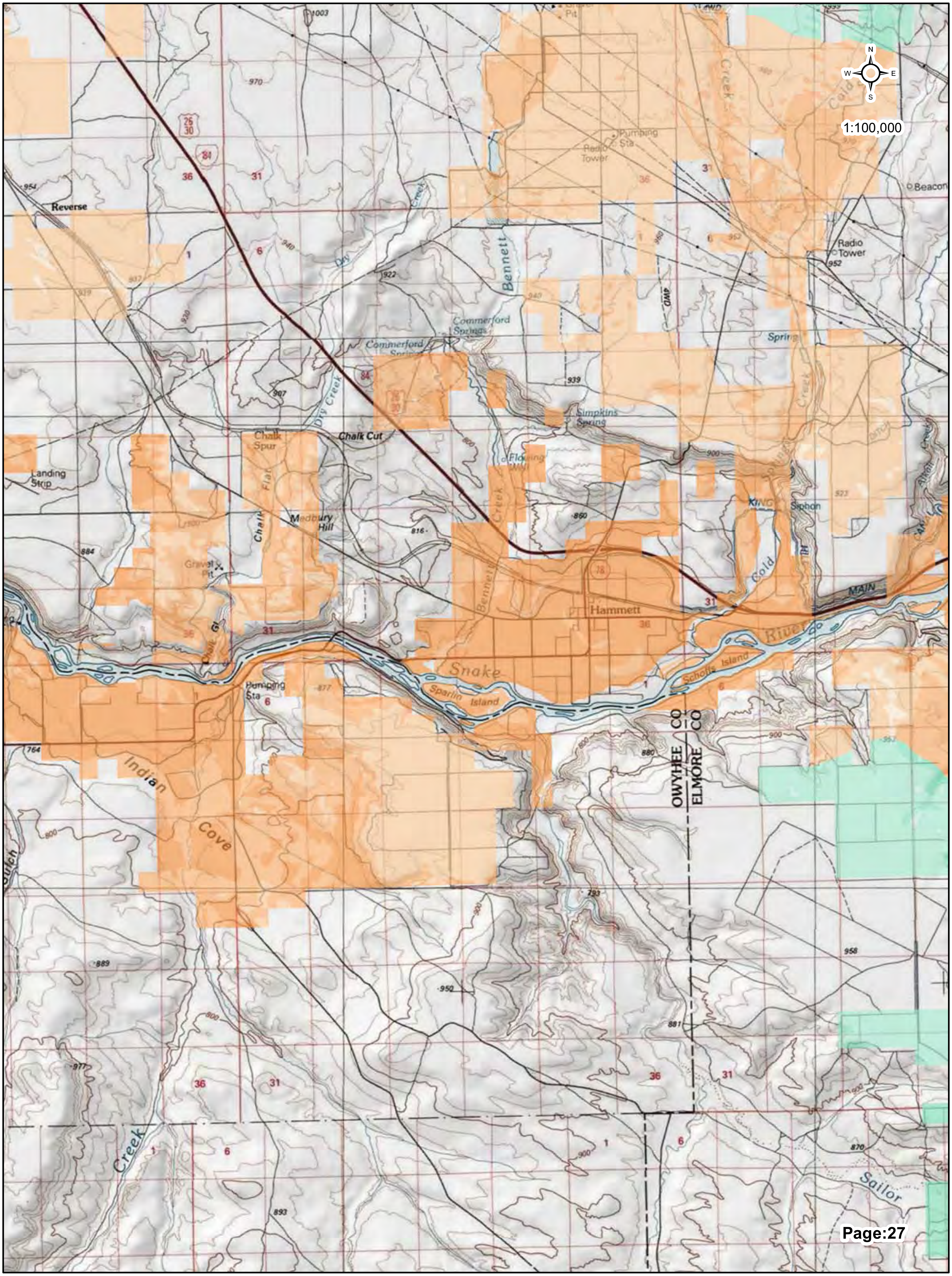
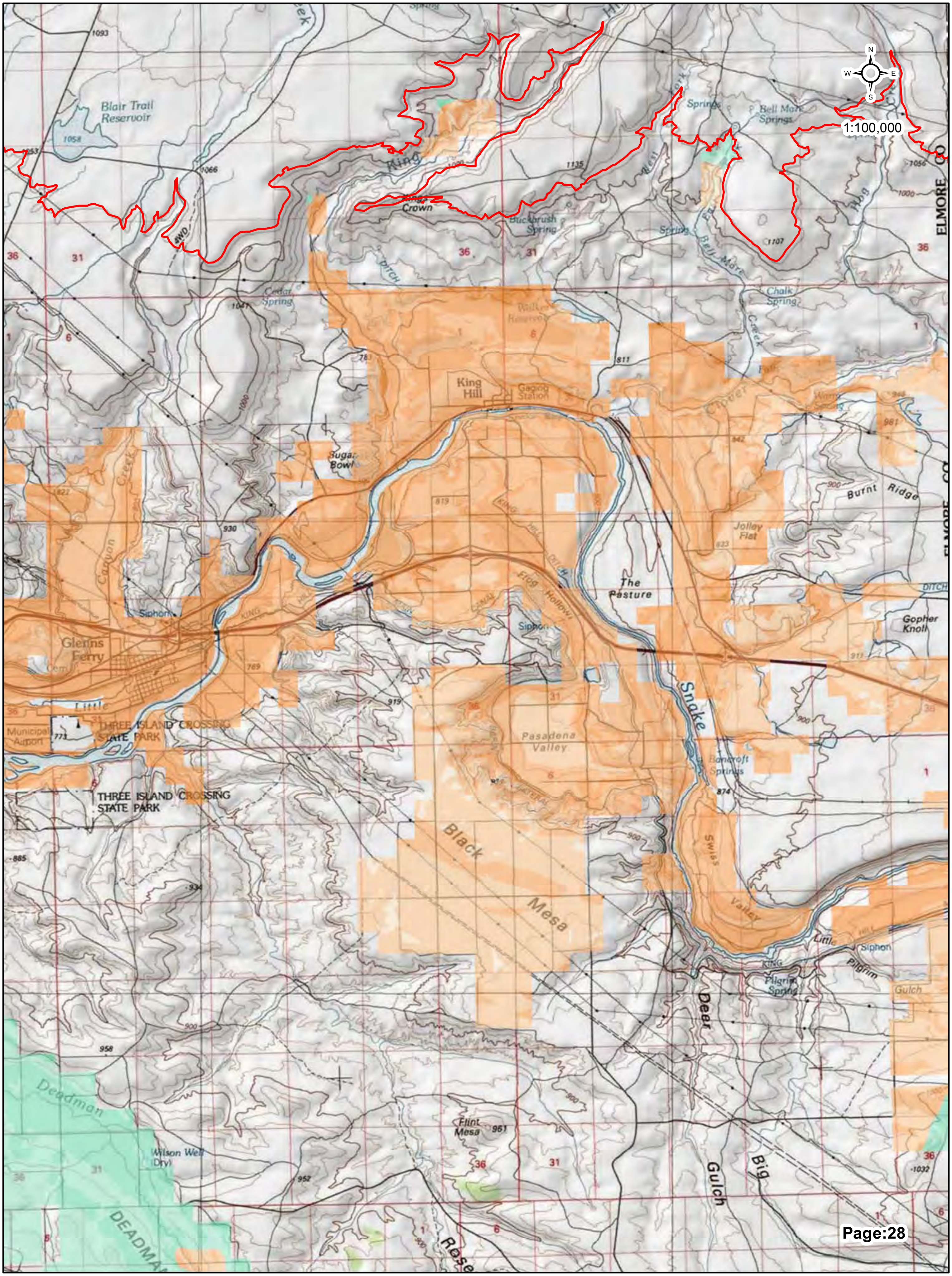
MOUNTAIN HOME
AIR FORCE BASE
Landing Strip
Gravel Pit
Rattlesnake
Beacons
Snake
River
Rattlesnake Creek
Rattlesnake Spring
Landing Strip
Grand View
EMIGRANT TRAIL
Wilkins
Gulch
RESERVOIR
Eagle Cove
BRUNEAU DUNES STATE PARK
Sand Dunes
Waterhouse Gulch
Bruneau
BRUNEAU
River
BUCKAROO
Valley
Wash
Landing Strip
Crane Falls



1:100,000
Reverse
Landing Strip
Chalk Spur
Chalk Cut
Medbury Hill
Gravel Pit
Commerford Springs
Simpkins Spring
Flowing Well
Bennett Creek
Dry Creek
Radio Tower
Pumping Sta
Beacon
King
Siphon
Cold Springs Creek
Hammett
Snake River
Sparlin Island
Schoffs Island
Pumping Sta
Indian Cove
OWYHEE CO
ELMORE CO
Sailor
Creek



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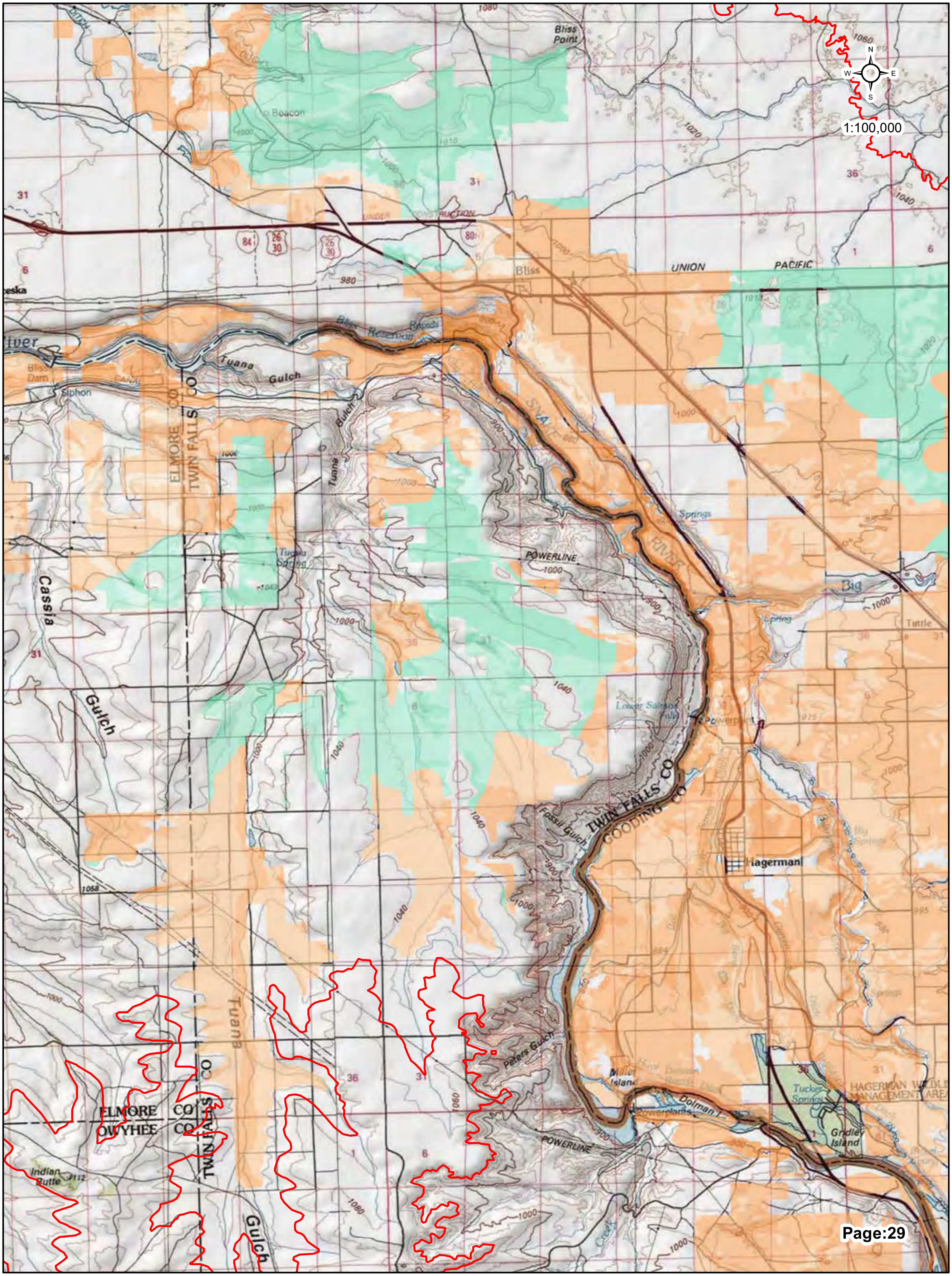
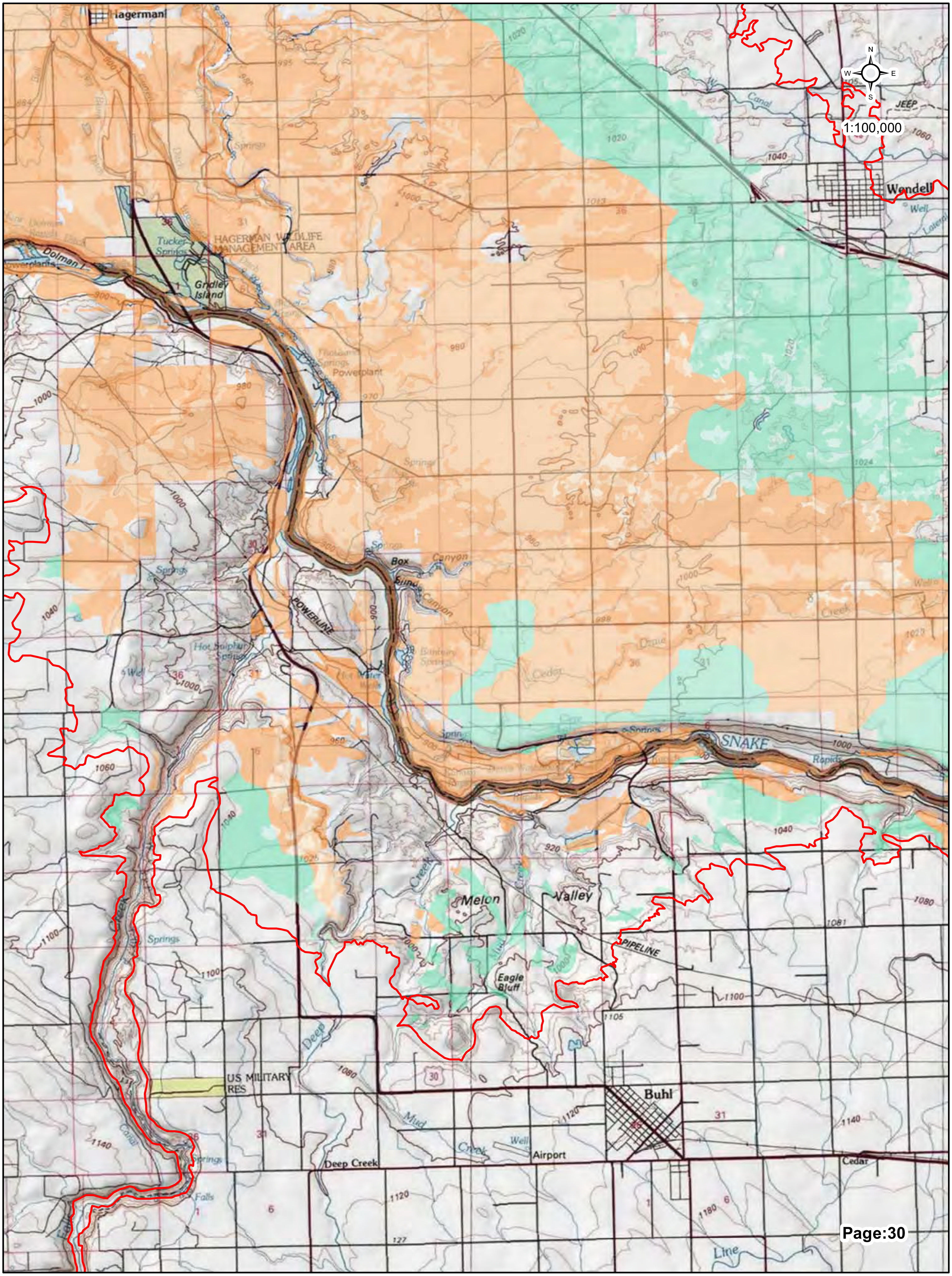
Blair Trail Reservoir
King Hill
Gaging Station
Sugar Bowl
Glenns Ferry
THREE ISLAND CROSSING STATE PARK
Municipal Airport
The Pasture
Gopher Knoll
Burnt Ridge
Jolley Flat
Clover
Snake
Pasadena Valley
Black Mesa
Swiss Valley
Bancroft Springs
Siphon
Pilgrim Spring
Deer Gulch
Big
Flint Mesa
Wilson Well (Dry)
Deadman
DEADMAN
Cedar Spring
Chalk Spring
Bell Mare Springs
Buckbrush Spring
Kings Crown
ELMORE CO
Canyon Creek
Frog Hollow
Little
Page:28



Bliss Point
Beacon
1:100,000
UNDER CONSTRUCTION
UNION
PACIFIC
Bliss
Bliss Reservoir
Rapids
River
Bliss Dam
Tuana Gulch
Siphon
ELMORE CO
TWIN FALLS CO
Tuana Gulch
Tuana Spring
Cassia
Gulch
SNAKE RIVER
Springs
POWERLINE
Big
Spring
Tuttle
Lower Salmon Falls
Powerplant
Fossil Gulch
TWIN FALLS CO
GOODING CO
Hagerman
Big Springs
Tuana
Peters Gulch
Miller Island
Tucker Springs
HAGERMAN WILDLIFE MANAGEMENT AREA
Gridley Island
Dolman
ELMORE CO
OWYHEE CO
Indian Butte
POWERLINE
Gulch
Creek



1:100,000
N
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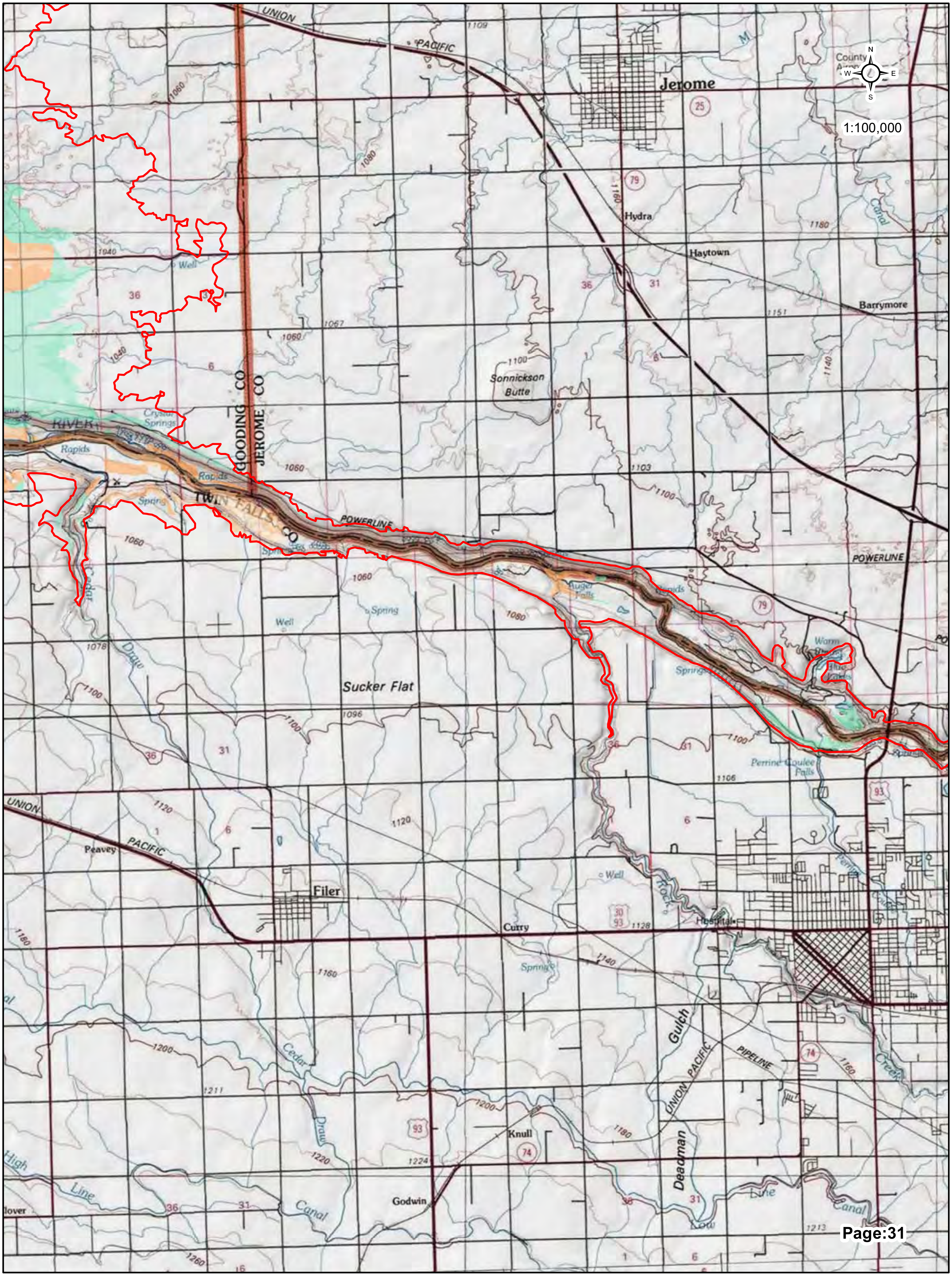
Hagerman
Wendell
HAGERMAN WILDLIFE MANAGEMENT AREA
Tucker Springs
Gridley Island
Dolman
Powerplant
Thousand Springs
Box Canyon
Blind Canyon
POWERLINE
Hot Sulphur Springs
Banbury Springs
SNAKE
Rapids
Melon
Valley
Eagle Bluff
PIPELINE
US MILITARY RES
Deep Creek
Mud Creek
Airport
Buhl
Cedar
Springs
Falls
Canal
JEEP
Page:30



1:100,000
N
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Jerome
Hydra
Haytown
Barrymore
Sonnickson Butte
GOODING CO
JEROME CO
TWIN FALLS CO
RIVER
Crystal Springs
Rapids
Spring
POWERLINE
UNION PACIFIC
Auger Falls
Warm Springs
Blue Lakes
Perrine Coulee Falls
Sucker Flat
Peavey
Filer
Curry
Hospital
Knull
Godwin
Deadman Gulch
Cedar Draw
Rock Creek
High Line Canal
Low Line Canal
PIPELINE
Well
Canal